Five Lakes Engineering Feasibility Study

LAGRANGE AND NOBLE COUNTIES, INDIANA

July 28, 2004

Prepared for:

Five Lakes Conservation Association
c/o Bob Christen
Wolcottville, Indiana 46795

Prepared by:

JFNew
708 Roosevelt Road
Walkerton, Indiana 46574
574-586-3400

EXECUTIVE SUMMARY

The Five Lakes, including Witmer, Dallas, Hackenburg, Messick, and Westler Lakes, and their watershed cover 37,248 acres (15,074 ha) in southern Lagrange and northern Noble Counties, Indiana. Little Elkhart Creek, the largest of the Five Lakes tributaries, drains 20,869 acres (8,447 ha). Water leaves the Five Lakes via the North Branch Elkhart River flowing northwesterly to the St. Joseph River and Lake Michigan.

Previous studies suggested that phosphorus was the limiting nutrient causing the lakes to be eutrophic. These studies suggested that Little Elkhart Creek carried the highest sediment and sediment-attached pollutant loads to the lakes. A single set of water chemistry data collected during the current study suggested that a tributary to Westler Lake contains heavy sediment and sediment-attached pollutant concentrations and carries high sediment and sediment-attached pollutant loads to the lakes. However, as a perennial stream, Little Elkhart Creek carries the highest annual sediment and sediment-attached pollutant loads to the lakes.

The feasibility of implementing three projects was pursued. The three projects are installing fencing along J.J. Charles Drain to restrict livestock access to the drain, altering and existing wetland to reduce the nutrient load in an unnamed tributary to Witmer Lake, and a construction of a grade control at the Mill Pond on Little Elkhart Creek to reduce sediment and sediment-attached pollutant loading. While all of these projects are considered feasible, only two of these projects are recommended for future design and construction. The design of the Mill Pond project and the J.J. Charles drain project were pursued and agreements made with landowners to secure access for construction.

ACKNOWLEDGEMENTS

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LAGRANGE AND NOBLE COUNTIES, INDIANA

1.0 INTRODUCTION

1.1 BACKGROUND

Witmer, Westler, Dallas, Hackenburg, and Messick Lakes, known collectively as the Five Lakes, have been the focus of several studies to address various problems facing the lakes. These problems include: increased quantities of aquatic plants and algae, increased sediment deposition within and at the mouth of tributaries, elevated nutrient levels, and decreased transparency. In 1990, the Five Lakes Conservation Association (FLCA) received Indiana Lake Enhancement Program T by 2000 funding to conduct a lake and watershed feasibility study. The study's purpose was to document existing conditions in the Indian Lakes chain, which includes the Five Lakes, and its watershed and to diagnose potential pollutant sources to the lakes (F.X. Browne, 1992). According to the study, Dallas Lake possessed good water quality but contained rooted plant growth problem areas; Hackenburg Lake was eutrophic and had poor water quality; Messick Lake was mesotrophic to eutrophic and possessed minor rooted plant growth problem areas; Westler and Witmer Lakes both possessed poor water quality, high suspended solids concentrations, and low transparency. Phosphorus modeling suggested that the majority of phosphorus loading to all five lakes originated from external sources in the watershed. The study recommended addressing watershed-level issues before attempting in-lake treatment. In 1999, the FLCA received a grant from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Program to conduct an engineering feasibility study to address problem areas identified in the 1992 F.X. Browne study. Through the completion of this study, Commonwealth Biomonitoring identified four specific problem sites within the watershed, then determined design and construction feasibility for these projects. In 2002, the FLCA received a feasibility/design study grant to continue working on the recommendations from the diagnostic and feasibility studies. The purpose of the current feasibility/design study is to determine design and construction feasibility for recommended projects within the Five Lakes Watershed and to finalize designs, obtain regulatory permits, and complete construction plans for one of the identified projects.

1.2 SCOPE OF STUDY

This feasibility/design study examines potential projects in Witmer, Westler, Dallas, Hackenburg, and Messick Lakes and their 37,248-acre (15,074-hectare or 58-square mile) watershed in Noble and Lagrange Counties. The study specifically targets the immediate watershed of the lakes including Little Elkhart Creek from Witmer Lake upstream to the town of Wolcottville and several smaller tributaries in the immediate vicinity of the lakes. The scope of the study included water quality sampling during storm flow conditions to determine which lake tributary contributed the highest pollutant loads, field surveys of the immediate watershed to identify locations where water quality improvement projects could be implemented, and individual public meetings with landowners and watershed stakeholders. Three potential projects (listed below) were identified during the course of this study. (Figure 1 shows the location of each project.) The feasibility of implementing each of these projects was examined. This report documents the results of this examination.

Potential water quality improvement projects investigated during this study include:

1. Grade control and sediment trap construction along Little Elkhart Creek, Witmer Lake
2. Livestock fencing along J.J. Charles Drain, Hackenburg Lake
3. Sediment and sediment-attached pollutant load reduction from the unnamed southern tributary, Witmer Lake

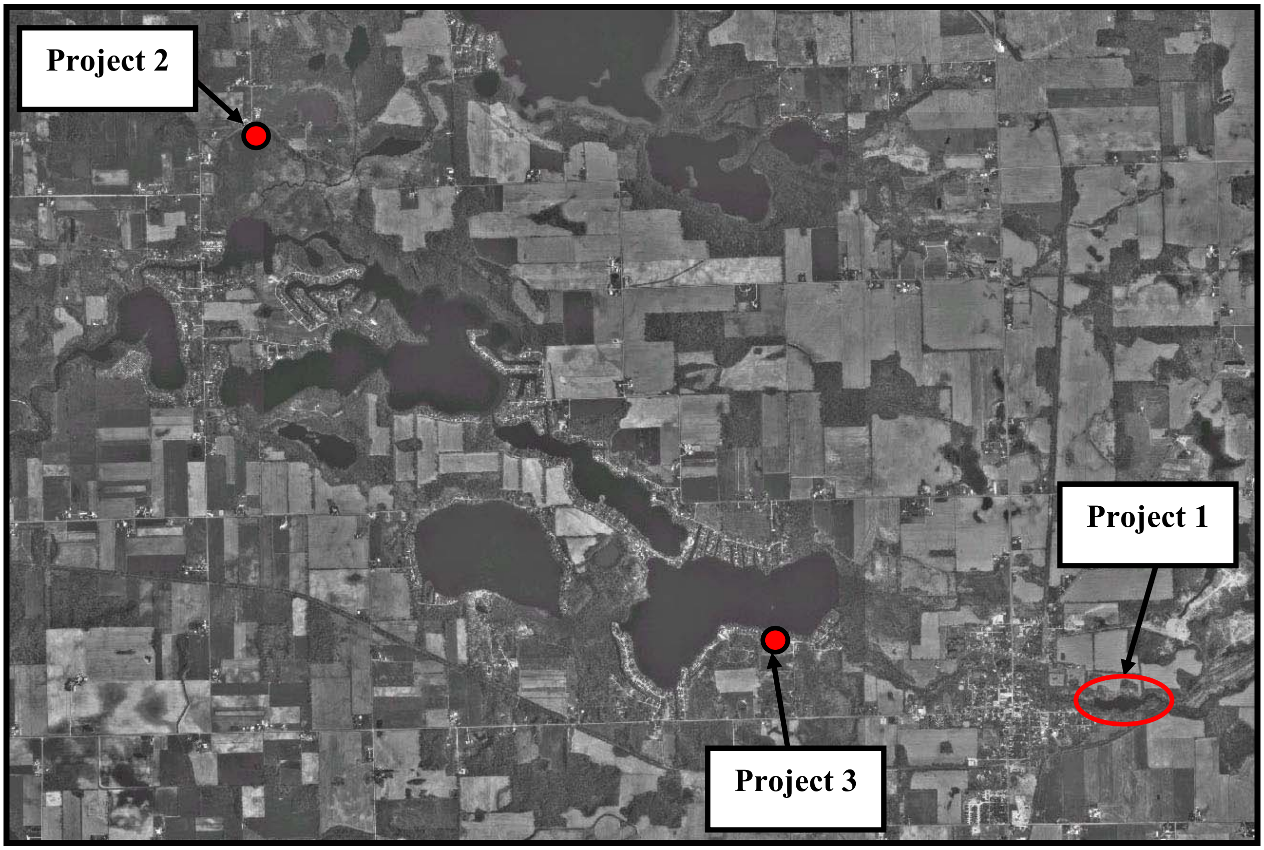

Figure 1. Engineering feasibility/design proposed project locations.

1.3 GOALS AND OBJECTIVES

The goal of this study is to identify feasible projects that can be designed and implemented within a reasonable time frame and to complete the design of, obtain permits for, and develop work plans for one of the feasible projects. A project is deemed feasible if it can be constructed, is acceptable to affected landowners, is economically justifiable, and will likely receive regulatory approval. The feasibility/design study attempts to ensure project success by investigating all avenues that could potentially cause project failure.

2.0 DESCRIPTION OF STUDY AREA

2.1 LOCATION

The Five Lakes Watershed encompasses 37,248 acres (15,074 ha) in southern Lagrange and northern Noble Counties, Indiana (Figures 2 and 3). The Five Lakes Watershed is part of the Elkhart River Basin, which conducts water to the St. Joseph River then into Lake Michigan. Five main drainages transport water from the watershed to the Five Lakes (Figure 4). Witmer

Lake has three main drainages: Little Elkhart Creek, which drains approximately 20,869 acres (8,447 ha), an unnamed tributary which flows north from the county line and drains approximately 594 acres (240 ha), and an unnamed tributary which flows east from Atwood Lake into Witmer Lake draining approximately 1,040 acres (421 ha). The main inlet to Westler Lake is an unnamed tributary located at the northeast corner of the lake which drains approximately 810 acres (328 ha). Westler Lake also receives water from Witmer Lake. Two stream channels carry water to Hackenburg Lake; these channels are J.J. Charles Drain which drains approximately 879 acres (356 ha) and an unnamed tributary from Oliver Lake which drains 8,995 acres (3,519 ha). About 4,363 acres (1,766 ha) of land drains either directly to the lakes or through minor tributaries before entering the lakes. Water drains from Witmer Lake into Westler Lake and Dallas Lake. Water flows from Dallas Lake into Hackenburg Lake and then into Messick Lake. Water drains from Messick Lake through the West Lakes chain of lakes, eventually reaching the North Branch Elkhart River. The North Branch Elkhart River in turn combines with the South Branch Elkhart River east of Ligonier to form the Elkhart River before entering the St. Joseph River.

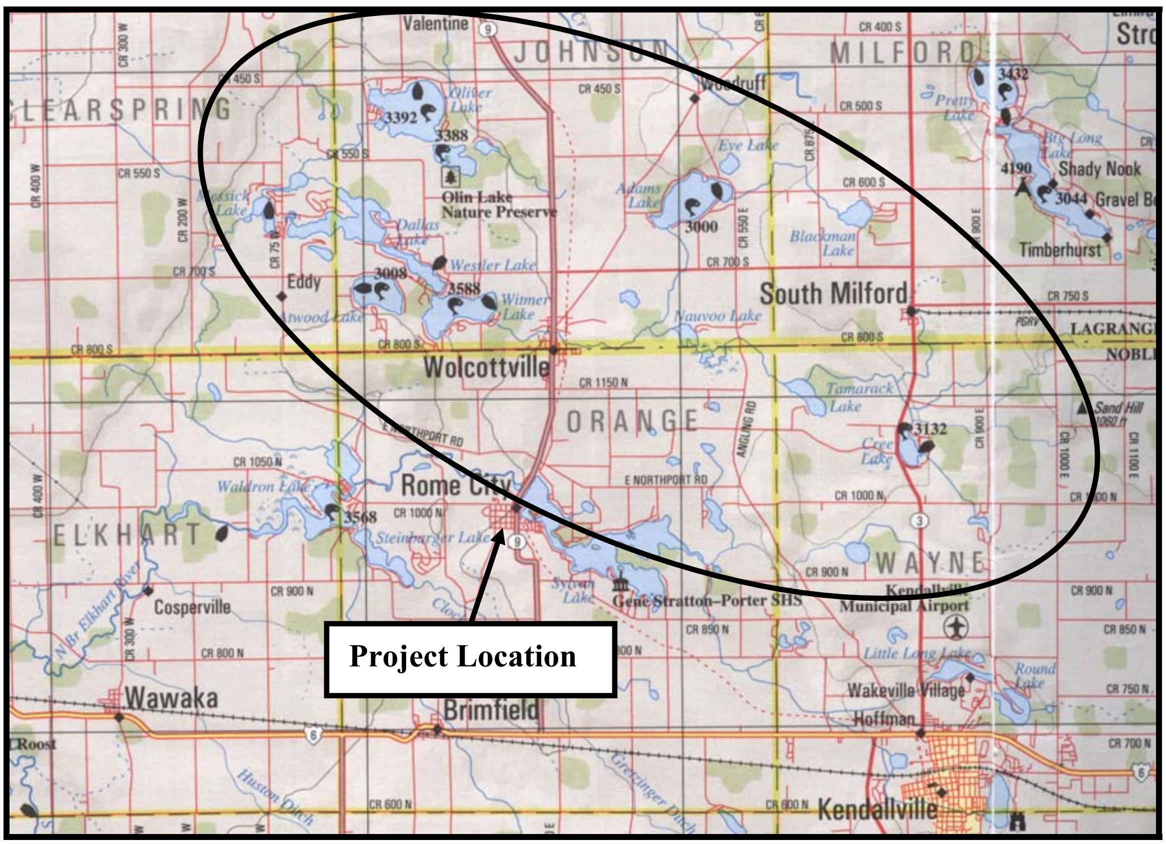

Figure 2. General location of the Five Lakes Watershed.

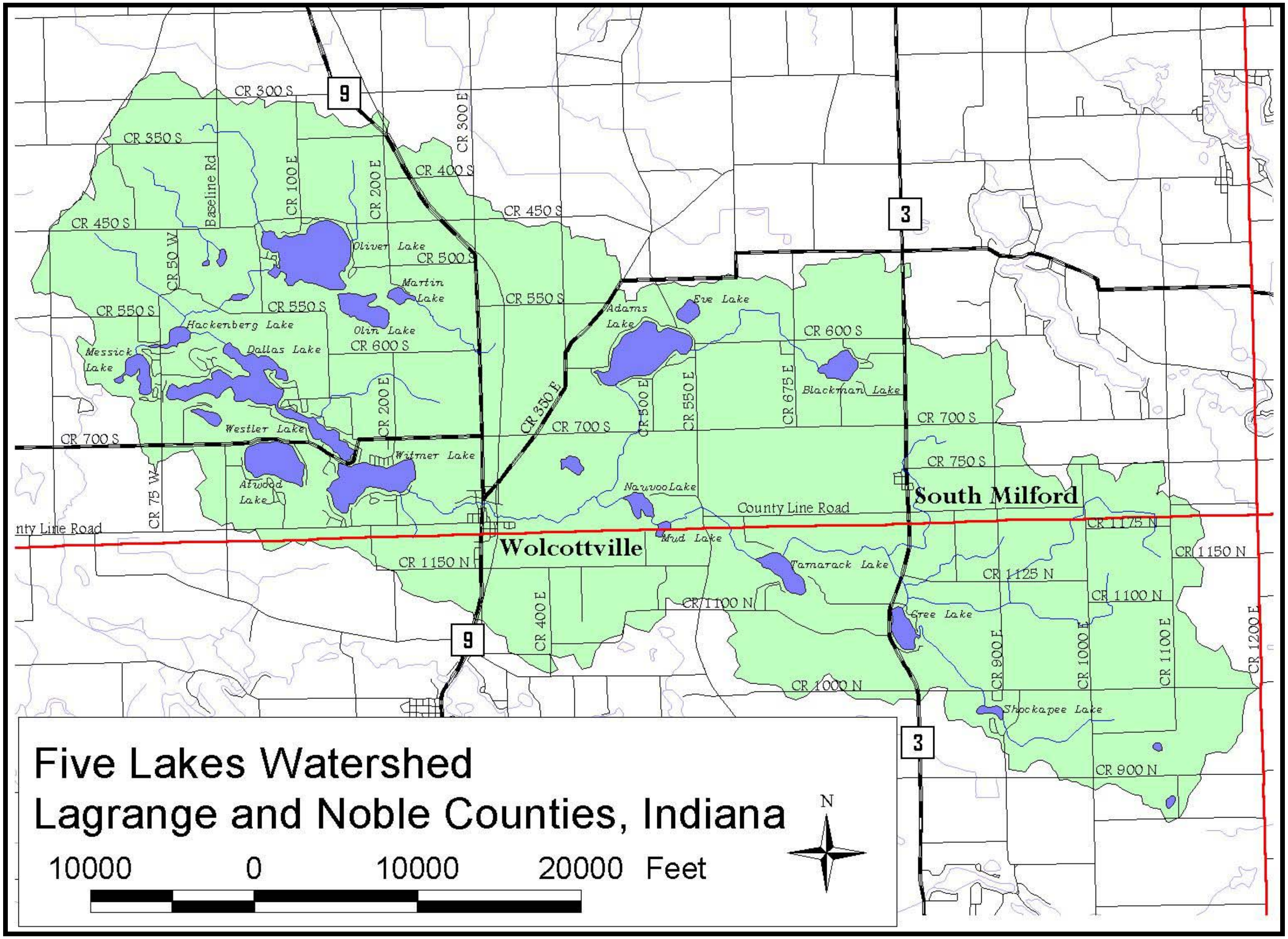

Figure 3. Five Lakes Watershed.

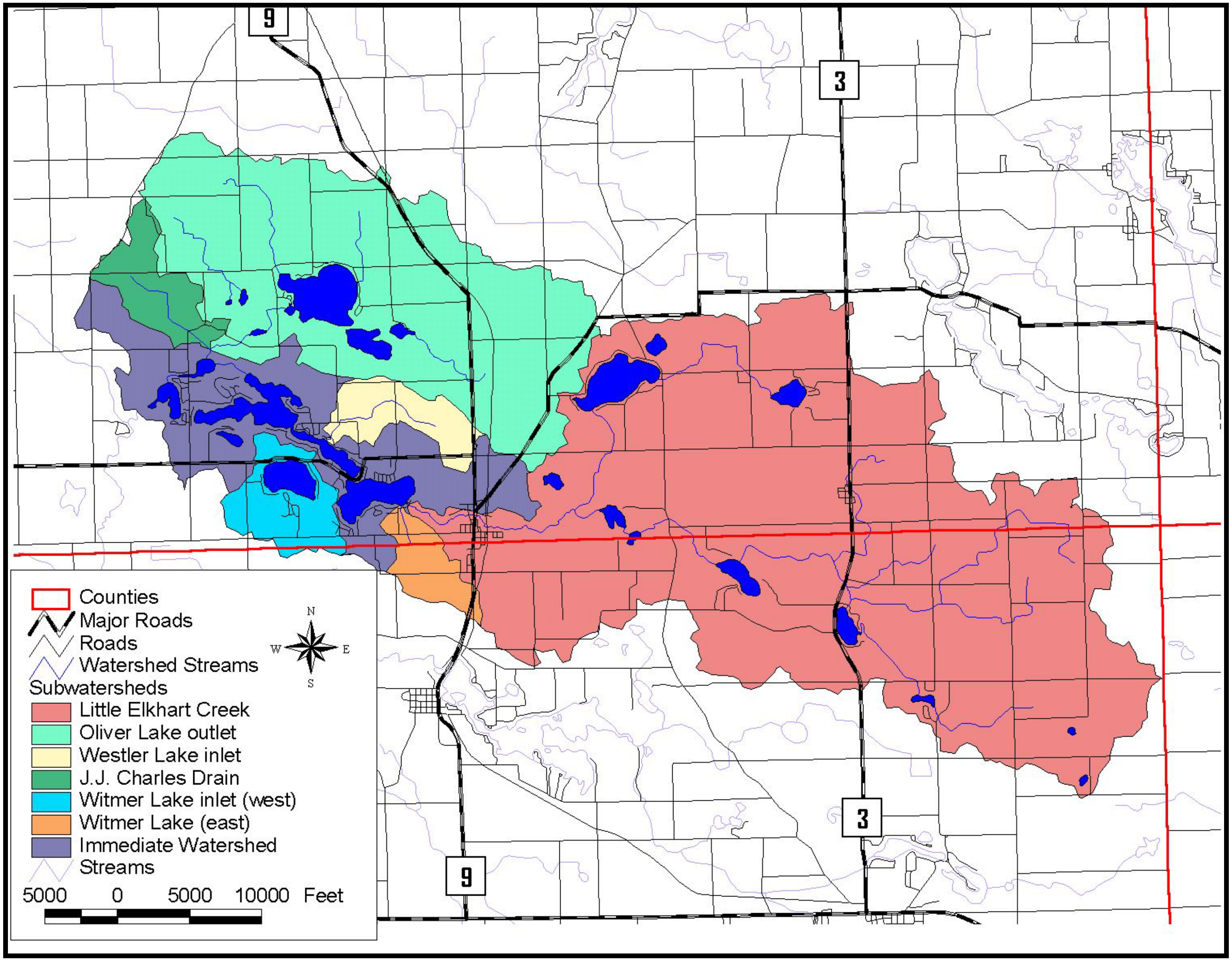

Figure 4. Five Lakes subwatersheds.

2.2 GEOLOGIC HISTORY AND TOPOGRAPHY

The Five Lakes and their watershed formed during the most recent glacial retreat of the Pleistocene era. The lakes and their watershed lien in northeastern Indiana where the advance and retreat of the Saginaw Lobe of a later Wisconsin age glacier as well as the deposits left by the lobe shaped much of the landscape found in northeastern Indiana (Homoya et al., 1985). The Saginaw Lobe retreat left a broad, flat to rolling glaciated plain, which has been classified as the Northern Till Plain Ecoregion (Omernik and Gallant, 1988). Glacial fill and outwash, sandy gravelly beach ridges, flat belts of morainal hills, and bog kettle depression characterize this ecoregion (Simon, 1997).

The topography of the Five Lakes Watershed is typical of much of Lagrange and Noble Counties and was determined to a large extent by glaciation. Land in the eastern portion of the lakes' watershed exhibits a gently rolling topography. Relief ranges from approximately 1070 feet above mean sea level (msl) at Sand Hill, the highest point in the watershed, to approximately 900 feet above msl at the lakes. Land in the immediate vicinity of the lakes is flatter than the land in the eastern part of the watershed with large wetland expanses lying adjacent to the lakes.

2.3 SOILS

The soil types found in the Five Lakes Watershed are a product of the original parent materials deposited by the glaciers that traversed the area 12,000 to 15,000 years ago (Figure 5). The Wawasee-Hillsdale-Conover soil association covers much of the watershed located in Lagrange County and is characterized by nearly level to strongly sloping, well drained and somewhat poorly drained, medium textured soils located on till plains and moraines (Hillis, 1980). The Miami-Riddles-Brookston soil association consists of well drained to very poorly drained, nearly level to moderately steeply sloped soils that formed on uplands; this soil association covers much of the watershed located in Noble County (McCarter, 1977). Glacial outwash soils dominate smaller areas of the watershed. These include two soils associations. The Fox-Oshtemo soil association consists of nearly level, well drained, moderately coarse to moderately fine textured soils and is located southeast of Wolcottville. The Boyer-Oshtemo soil association surrounds Witmer, Westler, Dallas, and Messick Lakes, borders the west and northwest shoreline of Adams Lake, and encompasses the Town of Wolcottville. Soils of this association are generally characterized as moderately steep, well drained, coarsely textured soils. Two very poorly drained muck soils, the Houghton-Adrian association and the Houghton-Edwards-Adrian associations are present within the watershed. The Houghton-Adrian soil association surrounds Hackenburg Lake and extends southwest towards Messick Lake and northeast to Olin, Oliver, and Martin Lakes. The Houghton-Edwards-Adrian association lies adjacent to the northwest shoreline of Cree Lake, surrounds Tamarack Lake, and extends along the streambed of the Little Elkhart Creek to the Noble County line. According to Agricultural Nonpoint Source (AGNPS) modeling, large portions of the direct watersheds for each of the lakes consist of highly erodible soils (F.X. Browne, 1992). Based on the AGNPS model, Hackenburg Lake's direct watershed contained the lowest percentage of highly erodible soils (20%), while Witmer Lake's direct watershed contained the highest percentage of highly erodible soils (57%).

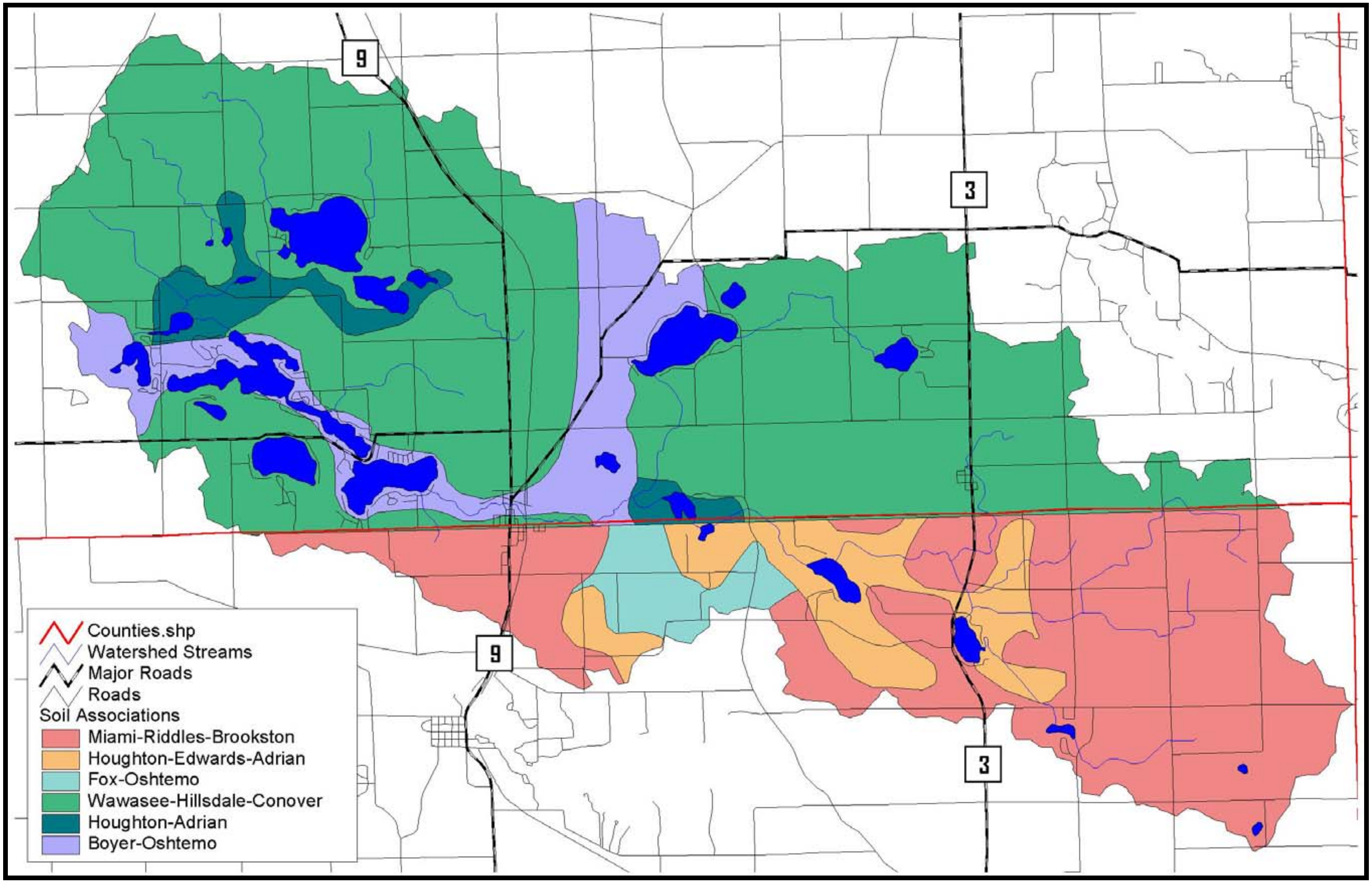

Figure 5. Five Lakes Watershed soil associations.

2.4 LAND USE

The Five Lakes Watershed lies within the Northern Lakes Natural Area (Homoya et al., 1985). Natural communities found in this region prior to European settlement included bogs, fens, marshes, prairies, sedge meadows, swamps, seep springs, lakes, and deciduous forests. Like much of the landscape in Lagrange and Noble Counties, a large portion of the Five Lakes Watershed was converted to agricultural land uses. Today, about 75% of the watershed is utilized for agricultural purposes including row crops and pasture (Table 1; Figure 6). An additional land use change has been residential development of much of the lakes' shorelines. Just over 1% of the watershed is mapped as low intensity residential land. Wetlands and open water account for approximately 13% of the total watershed, while forest land accounts for approximately 11% of the watershed.

Table 1. Land use in the Five Lakes Watershed.

Land Use	Area (acres)	Area (hectares)	% of Watershed
Row Crops	22,272.2	9,017.1	59.8%
Pasture/Hay	5,404.7	2,188.1	14.5%
Deciduous Forest	4,011.6	1,624.1	10.8%
Woody Wetlands	2,265.0	917.0	6.1%
Open Water	2,191.8	887.4	5.9%
Emergent Herbaceous Wetlands	543.0	219.8	1.5%
Low Intensity Residential	405.6	164.2	1.1%
High Intensity Commercial	65.2	26.4	0.2%
Evergreen Forest	43.3	17.5	0.1%
High Intensity Residential	21.0	8.5	0.1%
Quarries/Strip Mines/Gravel Pits	10.6	4.3	<0.1%
Transitional	9.7	3.9	<0.1%
Mixed Forest	4.6	1.9	<0.1%
TOTAL	**37,248.3**	**15,080.3**	**100.0%**

Source: USGS/EROS Indiana Land Cover Data Set, Version 98-12.

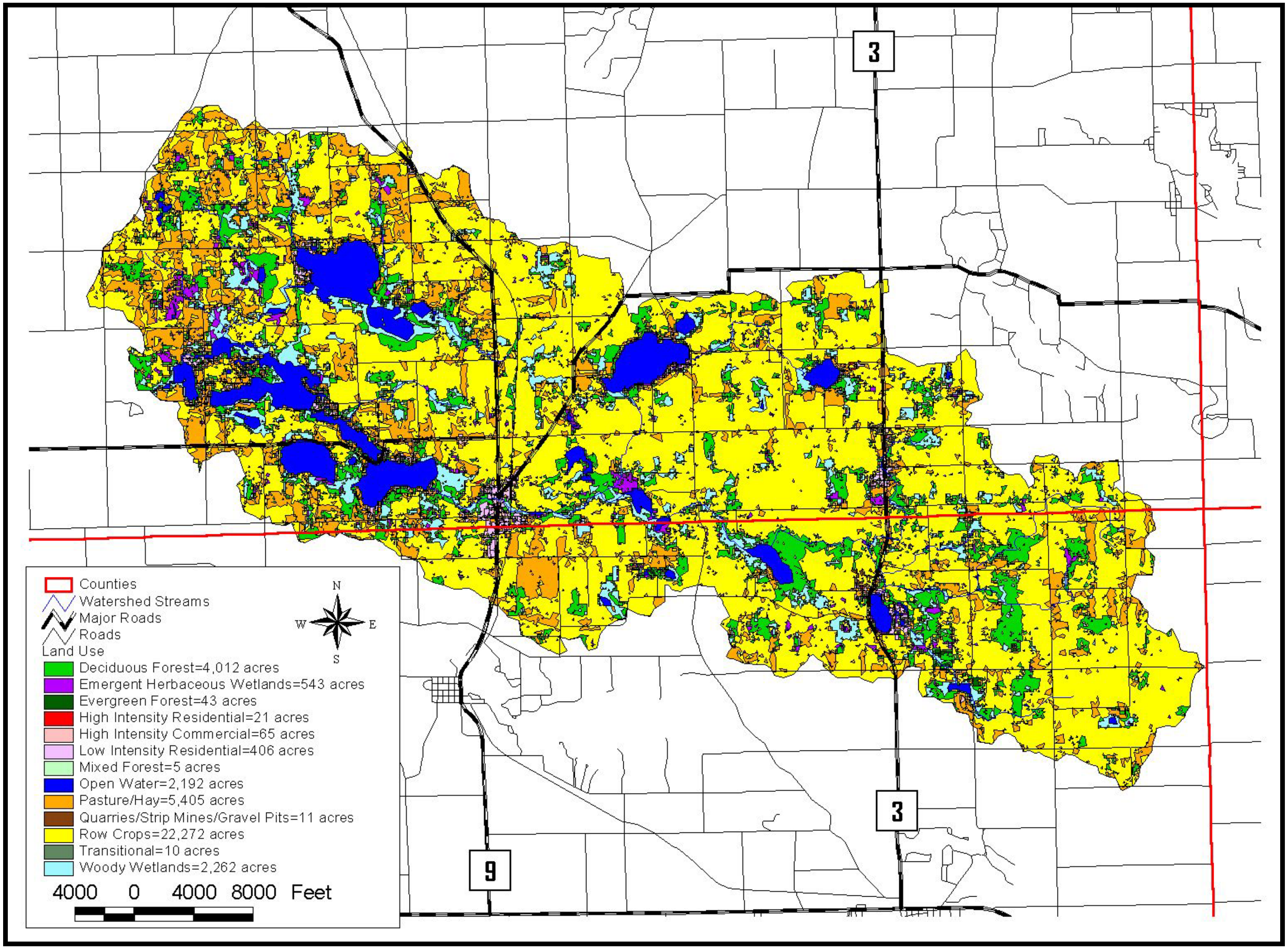

Figure 6. Five Lakes Watershed land use.

2.5 PRIOR STUDIES

Table 2 documents prior studies conducted in the Five Lakes and their watershed. Many of the historical studies focused on documenting and managing fisheries and in-lake water quality of the Five Lakes. More recent studies have focused on water quality in watershed streams and watershed management with the recognition that activities in the catchment of the lakes affect water quality in the lakes themselves. The 1990 feasibility study for Cree and Shockopee Lakes and the 1992 feasibility study for the Indian chain were the first to address watershed management of the areas draining into the Five Lakes. The 2000 watershed improvement project study and the 2001 feasibility study focused on addressing more specific issues in the Five Lakes Watershed.

Table 2. Current and prior studies conducted in the Five Lakes Watershed.

Year	Entity	Topic	Study
1950	Gerking	Fisheries	A Carp Removal Experiment at Oliver Lake, Indiana
1950	Gerking	Fisheries	Populations and Exploitation of Fishes in a Marl Lake
1950	Wolschlag	Fisheries	Vegetation and Invertebrate Life in a Marl Lake
1955	Frey	Fisheries	Distributional Ecology of the Cisco in Indiana
1955	IDNR, DOW	Water Quantity	Bathymetric Map, Dallas Lake
1955	IDNR, DOW	Water Quantity	Bathymetric Map, Hackenburg Lake
1955	IDNR, DOW	Water Quantity	Bathymetric Map, Messick Lake
1955	IDNR, DOW	Water Quantity	Bathymetric Map, Westler Lake
1964	IDNR, DFW	Fisheries	Fish Survey Report, Cree Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Atwood Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Dallas Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Hackenburg Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Messick Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Westler Lake
1967	IDNR, DFW	Fisheries	Lake Survey Report, Witmer Lake
1970	IDNR, DFW	Fisheries	Fish Management Report, Atwood Lake
1970	IDNR, DFW	Fisheries	Progress Report, Chinook Salmon in Oliver and Olin Lakes
1972	IDNR, DFW	Fisheries	Chinook Salmon Introduction in the Indian Lakes
1972	IDNR, DFW	Fisheries	Fish Management Report, Adams Lake
1972	IDNR, DFW	Fisheries	Fish Management Report, Cree Lake
1972	IDNR, DFW	Fisheries	Fish Management Report, Olin Lake
1972	IDNR, DFW	Fisheries	Fish Management Report, Oliver Lake

Year	Entity	Topic	Study
1972	IDNR, DFW	Fisheries	Pre-Fish Population Control Report, Atwood Lake
1973	IDNR, DFW	Fisheries	Fish Management Report, Martin Lake
1973	IDNR, DFW	Fisheries	Results of Chinook Salmon Introduction into Oliver and Olin Lakes
1974	IDNR, DFW	Fisheries	Fish Management Report, Adams Lake
1974	IDNR, DFW	Fisheries	Revised Creel Census for the Oliver Lakes Chain
1975	IDNR, DFW	Fisheries	Fish Management Report, Cree Lake
1975	IDNR, DFW	Fisheries	Fish Management Report, Oliver Lake
1976	IDNR, DFW	Fisheries	Fish Management Report, Oliver Lake
1976	USEPA	Water Quality	National Eutrophication Survey, Dallas Lake
1976	USEPA	Water Quality	National Eutrophication Survey, Olin Lake
1976	USEPA	Water Quality	National Eutrophication Survey Report, Oliver Lake
1976	USEPA	Water Quality	National Eutrophication Survey Report, Westler Lake
1976	USEPA	Water Quality	National Eutrophication Survey Report, Witmer Lake
1977	IDNR, DFW	Fisheries	Fish Management Report, Messick Lake
1977	IDNR, DFW	Fisheries	Fish Management Report, Oliver Lake
1977	IDNR, DFW	Fisheries	Fish Management Report, Westler Lake
1977	IDNR, DFW	Fisheries	Lake Survey Report, Witmer Lake
1978	IDNR, DFW	Fisheries	Lake Survey Report, Dallas Lake
1978	IDNR, DFW	Fisheries	Fish Management Report, Messick Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Atwood Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Dallas Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Hackenburg Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Messick Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Westler Lake
1982	IDNR, DFW	Fisheries	Fish Management Report, Witmer Lake
1982	IDNR, DFW	Fisheries	Spot Check Survey, Adams Lake
1983	IDNR, DFW	Fisheries	Fish Management Report, Martin Lake
1983	IDNR, DFW	Fisheries	Fish Management Report, Olin Lake
1983	IDNR, DFW	Fisheries	Fish Management Report, Oliver Lake
1984	IDNR, DFW	Fisheries	Fish Management Report, Hackenburg Lake
1984	IDNR, DFW	Fisheries	Fish Management Report, Westler Lake
1984	IDNR, DFW	Fisheries	Spot Check Survey, Adams Lake
1984	IDNR, DFW	Fisheries	Spot Check Survey, Atwood Lake
1986	IDNR, DFW	Fisheries	Fish Management Report, Olin Lake
1986	IDEM, OWQ	Water Quality	Indiana Lake Classification System and Management Plan

Year	Entity	Topic	Study
1987	IDNR, DFW	Fisheries	An Evaluation of Survival and Growth of Pellet-Reared Tiger Muskellunge Stocked into Three Natural Lakes
1987	IDNR, DFW	Fisheries	Spot Check Survey, Adams Lake
1987	IDNR, DFW	Fisheries	Spot Check Report, Atwood Lake
1988	IDNR, DFW	Fisheries	Fish Management Report, Atwood Lake
1988	LCHD	Water Quality	A Preliminary Investigation of Twenty-four Lakes, Lagrange County, Indiana
1988	IDNR, DFW	Fisheries	Spot Check Report, Adams Lake
1988	IDNR, DFW	Fisheries	Spot Check Survey, Witmer Lake
1989	IDNR, DFW	Fisheries	Fish Management Report, Adams Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Adams Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Atwood Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Blackman Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Cree Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Hackenburg Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Messick Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Westler Lake
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Witmer Lake
1989	IDNR, DFW	Fisheries	Tiger Muskie Management Report, Adams Lake
1990	IDNR, DSC; ISTI	Watershed Management	Feasibility Study for Cree and Shockopee Lakes
1990	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Martin Lake
1990	Spacie and Loeb	Water Quality	Long-term Trends in Trophic State of Indiana Lakes Following Phosphorus Reduction
1990	IDNR, DFW	Fisheries	A Survey of Fish harvest at the Oliver Lake Chain
1990	IDNR, DFW	Fisheries	Tiger Muskie Management Report, Adams Lake
1990	IDNR, DFW	Fisheries	Trout Management Report, Olin Lake
1991	IDNR, DFW	Fisheries	Fish Management Report, Blackman Lake
1991	IDNR, DFW	Fisheries	Fish Management Report, Cree Lake
1991 to 1994	IDNR, DSC; NCSWCD	Watershed Management	Watershed Land Treatment Program, Cree and Shockopee Lake Tributaries
1992	IDNR, DSC; FXBAI	Watershed Management	Feasibility Study of Ten Lagrange County Lakes

Year	Entity	Topic	Study
1992	IDNR, DFW	Fisheries	A Survey of the Adams Lake Fish Population and Fish Harvest
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Adams Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Atwood Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Blackman Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Cree Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Dallas Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Hackenburg Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Martin Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Messick Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Nauvoo Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Olin Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Oliver Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Shockopee Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Tamarack Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Westler Lake
1993	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Witmer Lake
1993 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk, Total Phosphorus, and Chlorophyll *a* Monitoring of Martin Lake
1993 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk, Total Phosphorus, and Chlorophyll *a* Monitoring of Olin Lake
1993 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk, Total Phosphorus, and Chlorophyll *a* Monitoring of Oliver Lake
1994	IDNR, DFW	Fisheries	Fish Management Report, Cree Lake
1994	IDNR, DFW	Fisheries	Fish Survey Report, Shockopee Lake
1994	IDNR, DFW	Fisheries	Fish Survey Report, Tamarack Lake
1994	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Eve Lake
1997 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk Monitoring on Dallas Lake
1997 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk Monitoring on Westler Lake
1997 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk Monitoring on Witmer Lake
1997 to 2002	IDNR, DSC; FLCA; LCSWCD	Watershed Management	Watershed Land Treatment Project, Witmer Lake

Year	Entity	Topic	Study
1998	IDNR, DFW	Fisheries	Fish Management Report, Dallas Lake
1998	IDNR, DFW	Fisheries	Fish Management Report, Hackenburg Lake
1998	IDNR, DFW	Fisheries	Fish Management Report, Messick Lake
1998	IDNR, DFW	Fisheries	Fish Management Report, Westler Lake
1998	IDNR, DFW	Fisheries	Fish Management Report, Witmer Lake
1998	IDNR, DSC	Aquatic Plant Management	Indiana Lakes Exotic Plant Survey
1998	LCHD	Water Quality	Movement of Septic System Effluent from Lake Developments into Near-Shore Areas of 18 Indiana Lakes
1998 to present	IDEM, IVMP	Water Quality	Seasonal Secchi Disk Monitoring on Adams Lake
2000	IDEM, BSS	Water Quality	Corvallis Sampling Program, Uhl Ditch
2000	IDEM, BSS	Water Quality	*E. coli* Sampling Program, Cree Lake Outlet
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Adams Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Atwood Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Blackman Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Cree Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Dallas Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Hackenburg Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Martin Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Messick Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Olin Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Oliver Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Shockopee Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Westler Lake
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment, Witmer Lake
2000	IDNR, DSC	Aquatic Plant Management	Innovative Treatment Grant, Atwood Lake
2000	IDEM, BSS	Water Quality	Macroinvertebrate Collection, Witmer Lake
2000	IDEM, OWM; CBI	Watershed Management	Recommendations for Some Agricultural Best Management Practices (BMPs), Indian Lakes Chain
2000	IDEM, WSM	Watershed Management	St. Joseph River (Lake Michigan) Watershed Restoration Action Strategy
2000	HR; OLIA	Water Quality	Volunteer Stream Monitoring, Oliver Lake Inlets

Year	Entity	Topic	Study
2001	IDNR, DSC; CBI	Watershed Management	Indian Lakes Improvement Project
2003 to present	IDNR, DSC; JFNew	Watershed Management	Five Lakes Engineering Feasibility Study and Design Project
2003 to present	IDEM, OWM; DJCase; JFNew	Watershed Management	Five Lakes Watershed Management Plan

CBI=Commonwealth Biomonitoring, Incorporated
FLCA=Five Lakes Conservation Association
FXBAI=F.X. Browne Associates, Incorporated
HR=Hoosier Riverwatch
IDEM, BSS=Indiana Department of Environmental Management, Biological Studies Section
IDEM, CLP=Indiana Department of Environmental Management, Clean Lakes Program
IDEM, IVMP=Indiana Department of Environmental Management, Indiana Volunteer Monitoring Program
IDEM, OWM=Indiana Department of Environmental Management, Office of Water Management
IDEM, WMS=Indiana Department of Environmental Management, Watershed Management Section
OWQ=Indiana Department of Environmental Management, Office of Water Quality
IDNR, DFW=Indiana Department of Natural Resources, Division of Fish and Wildlife
IDNR, DOW=Indiana Department of Natural Resources, Division of Water
IDNR, DSC= Indiana Department of Natural Resources, Division of Soil Conservation
ISTI=International Science and Technology, Incorporated
LCHD=Lagrange County Health Department
LCSWCD=Lagrange County Soil and Water Conservation District
OLIA=Oliver Lake Improvement Association
USEPA=United States Environmental Protection Agency

Many of the studies listed in Table 2 include recommendations to improve specific aspects (fisheries, water chemistry, rooted plant population) of the Five Lakes Watershed and lakes within the watershed. This current study explores the feasibility of implementing the agricultural best management practice portion of one of the primary recommendations made in the 1992 Feasibility Study of Ten Lagrange County Lakes: *implement agricultural best management practices, homeowner best management practices, wastewater management practices, and stabilization practices for roadways and streambanks and establish erosion control and stormwater runoff ordinances for the entire area bounded by the ten lakes watershed*. This project also continues work started in the 2000 Recommendations for Some Agricultural Best Management Practices (BMPs), Indian Lakes Chain and the 2001 Indian Lakes Improvement Project by expanding two of the recommendations made in these studies and defining feasible projects that landowners are willing to implement.

3.0 STREAM WATER QUALITY INVESTIGATION

This feasibility study included the assessment of several of the Five Lakes tributaries to determine which tributaries contributed the greatest amount of pollutants to the Five Lakes. The water quality assessment portion of this study consisted of water chemistry sampling during a storm water runoff event. Analysis of water quality parameters in inlet streams is important for understanding what is being introduced to the lakes from their watershed. The data assists in guiding the prioritization of management actions and directing those actions toward the most critical areas.

3.1 METHODS

The sampling event occurred on July 7, 2003 following two days of rain. Local monitoring stations reported precipitation totals of approximately 0.75 to 1.5 inches for the 48 hours of July 5 and 6, 2003 in Lagrange and Noble Counties (Purdue Applied Meteorology Group, 2003). Based on the precipitation, the July 7, 2003 sampling effort documented storm flow conditions in the watershed streams. Following storm events, the increased overland water flow results in increased erosion of soil and nutrients from the land. In addition, precipitation washes pollutants from hardscape in the watershed. Thus, stream concentrations of nutrients and sediment are typically higher following storm events. In essence, storm sampling presents a "worst case" picture of watershed pollutant loading.

On July 7, 2003, biologists attempted to collect water quality samples from the five tributary sites. Two of the tributaries, J.J. Charles Drain and the unnamed tributary to Westler Lake, were not flowing despite the recent rain of July 5 and 6. Biologists collected water quality samples from the three remaining sites, Little Elkhart Creek, the Oliver Lake outlet, and the unnamed tributary to Witmer Lake. After these samples were collected, it began to rain. The rain event lasted approximately 30 minutes. Biologists revisited the two sites, J.J. Charles Drain and the unnamed tributary to Westler Lake, where water quality samples could not be collected following this 30-minute rain event on July 7. Biologists collected a water quality sample from the unnamed tributary to Westler Lake following the 30-minute rain event. However, because there was no flow in J.J. Charles Drain following the 30-minute rain event, a water quality sample could not be collected.

Table 3. Detailed sampling location information for the Five Lakes Watershed.

Site	Stream name	Road location	Place sampled
1	Little Elkhart Creek	SR 9	downstream of SR9 in town park
2	Unnamed Tributary (Witmer Lake)	CR 765 S	downstream of road crossing
3	Unnamed Tributary (Westler Lake)	CR 650 S	upstream of road crossing
4	Oliver Lake Outlet	CR 550 S	downstream of road crossing
5	J.J. Charles Drain	CR 75 W	no sample collected

Collected samples were stored on ice and transported the same day as collection to EIS Analytical Laboratories in South Bend, Indiana. The water quality samples were analyzed for a variety of physical, biological, and chemical parameters. The following is a brief description of each of these parameters.

Temperature

Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Likewise, water temperature regulates the species composition and activity of life associated with the aquatic environment. Since essentially all aquatic organisms are cold-blooded the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana streams. Temperatures should not exceed 32.2º C by more than 1.7 ºC during the month of July. (Water quality sample collection for this assessment occurred during this month.) In addition, the Indiana Administrative Code (IAC) states that "the maximum temperature rise at any time or place…shall not exceed 2.8 ºC in streams ..."

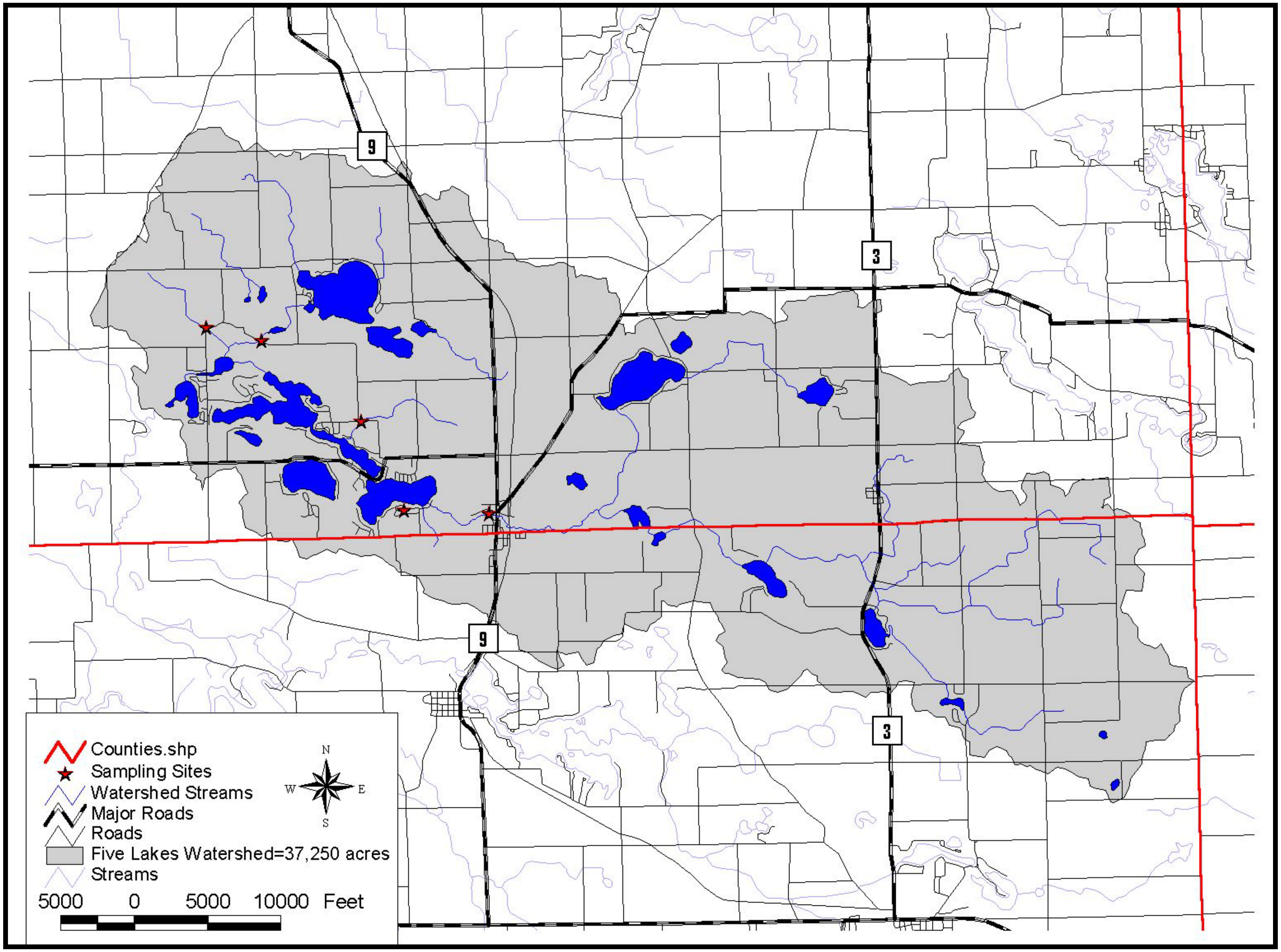

Figure 7. Sampling site locations in the Five Lakes Watershed.

Dissolved Oxygen
Dissolved oxygen (DO) is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need water to possess a DO concentration of at least 3-5 mg/l. The IAC requires that all waterbodies possess a daily dissolved oxygen average concentration of at least 5 mg/l and that at no time shall the DO concentration drop below 4 mg/l. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth, accompanied by high levels of photosynthetic activity, can oversaturate (greater than 100% saturation) the water with DO. Dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

pH
The pH of water describes the concentration of acidic ions (specifically H^+) present in water. The pH also determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6 to 9 pH units for the protection of aquatic life. pH concentrations in excess of 9 are acceptable only when occurring as daily fluctuations associated with photosynthetic activity.

Nutrients (Nitrogen and Phosphorus)
Nutrients are a necessary component of aquatic ecosystems. Ecosystem primary producers (i.e. plants) require nutrients for growth. Growth of the primary producers ultimately supports the remainder of the organisms in the ecosystem's food web. Insufficient nutrient levels in stream water can limit the size and complexity of biological communities living in the stream or lake. In contrast, excessive levels of nutrients in stream water alter biological communities by promoting nuisance species growth. For example, high concentrations of total phosphorus in lake water (>0.03 mg/l) create ideal conditions for nuisance algae growth. In extreme cases, lake algae growth can exclude rooted macrophyte growth and shift fish community composition.

Phosphorus and nitrogen are common nutrients governing plant growth. (When diatoms dominate the periphyton or planktonic community, silica is also an important nutrient.) Sources of phosphorus and nitrogen include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches streams. Nitrogen can also diffuse from the air into streams. Atmospheric nitrogen is then "fixed" by certain algae species (cyanobacteria) into a usable form of nitrogen. Because of this readily available source of nitrogen (the air), phosphorus is usually the "limiting nutrient" in aquatic ecosystems.

Phosphorus and nitrogen exist in several forms in water. The two common phosphorus forms are soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus for growth. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), and total Kjeldahl nitrogen (TKN). Nitrate is a dissolved form of nitrogen that is commonly found in surface water where oxygen is readily available. In contrast, ammonia-nitrogen is generally found in water where oxygen is lacking. Ammonia-nitrogen, or more correctly the ionized form of ammonia-nitrogen (ammonium), is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the total organic nitrogen (particulate) and ammonia-nitrogen in the water sample.

While the United States Environmental Protection Agency (USEPA) has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of streams. (The USEPA, in conjunction with the States, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for streams (USEPA, 2000). While these are not part of the Indiana Administrative Code, they serve as potential target conditions for which watershed managers might aim. The Ohio EPA has also made recommendations for numeric nutrient criteria in streams based on research on Ohio streams (Ohio EPA, 1999). These too serve as potential target conditions for those who manage Indiana streams. Other researchers have suggested thresholds for several nutrients in aquatic ecosystems as well (Dodd et al., 1998). The Indiana Administrative Code (IAC) requires that all waters of the state have a nitrate concentration of less than 10 mg/l, which is the drinking water standard for the state. Nitrate-nitrogen concentrations exceeding 10 mg/l in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6). Because both temperature and pH govern the toxicity of ammonia for aquatic life, these factors are weighed in the ammonia standard. Depending on the temperature and pH range of the study streams maximum unionized ammonia-nitrogen concentrations should not exceed 4.4 mg/l to 14.3 mg/l.

Researchers have recommended thresholds and criteria for nutrients in streams. The USEPA's recommended targets for nutrient levels in streams are fairly low. The agency recommends a target total phosphorus concentration of 0.033 mg/l in streams (USEPA, 2000). Dodd et al. (1998) suggest the dividing line between moderately (mesotrophic) and highly (eutrophic) productive streams is a total phosphorus concentration of 0.07 mg/l. The Ohio EPA recommended a total phosphorus concentration of 0.1 mg/l in wadeable streams to protect the streams' aquatic biotic integrity (Ohio EPA, 1999). (This criterion is for streams classified as Warmwater Habitat, or WWH, meaning the stream is capable of supporting a healthy, diverse warmwater fauna. Little Elkhart Creek (Site 1) and the Oliver Lake outlet (Site 4) would likely fit this definition. Streams that cannot support a healthy, diverse community of warmwater fauna due to "irretrievable, extensive, man-induced modification" are classified as Modified Warmwater Habitat (MWH) streams. The two unnamed inlets (Sites 2 and 3) would fit this definition. For MWH headwater streams, the Ohio EPA recommends a target total phosphorus concentration of 0.34 mg/l.

The USEPA also sets aggressive nitrogen criteria for streams recommendations compared to the Ohio EPA. The USEPA's recommended criteria for nitrate-nitrogen and total Kjeldahl nitrogen for streams in Aggregate Nutrient Ecoregion VII, which includes the Five Lakes Watershed, are 0.30 mg/l and 0.24 mg/l, respectively (USEPA, 2000). In contrast, the Ohio EPA suggests using a nitrate-nitrogen criterion of 1.0 mg/l in WWH wadeable (comparable to Little Elkhart Creek, Site 1) and WWH and MWH headwater (comparable to the Oliver Lake outlet, Site 4, and the unnamed tributaries to Witmer and Westler Lakes, Sites 2 and 3, respectively) streams to protect aquatic life. Dodd et al. (1998) suggests the dividing line between moderately and highly productive streams using nitrate-nitrogen concentrations is approximately 1.5 mg/l.

Total suspended solids
Total suspended solids refer to all particles suspended or dissolved in stream water. Sediment, or dirt, is the most common solid suspended in stream water. The sediment in stream water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks. The state of Indiana does not have a total suspended solids (TSS) standard. In general, TSS concentrations greater than 80 mg/l have been found to be deleterious to aquatic life (Waters, 1995).

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. In lakes and reservoirs, sediment accumulation limits boating opportunities and shortens the waterbody's lifespan. Similarly, few people are enthusiastic about having a picnic near a muddy creek or wading in silty water. Pollutants attached to sediment also degrade water quality.

Pathogens
Bacteria, viruses, and other pathogens are contaminants of concern in both rural and urban watersheds. Common sources of these pathogens include human and wildlife waste, fertilizers containing manure, previously contaminated sediments, septic tank leachate, and illicit connections to stormwater sewers or drainage tiles. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. Thus, pathogens can impair the recreational value of a stream. Some pathogens can also impair biological communities. Water quality researchers and monitoring programs utilize *E. coli* as an indicator for the presence of pathogens in water. According to the Indiana Administrative Code, *E. coli* concentrations should not exceed 235 colonies/100 ml in any one sample within a 30-day period.

3.2 WATER QUALITY RESULTS AND DISCUSSION
There are two useful ways to report water quality data in flowing water. *Concentrations* express the mass of a substance per unit volume, for example milligrams of total suspended solids per liter (mg/l). *Mass loading* describes the mass of a particular material being carried per unit time (kg/d). Loading is important when comparing among sites and among sampling dates because: 1) flow can be highly variable, therefore normalizing concentrations to flow eliminates variability; and 2) delivery of materials is important to consider. For example, a stream with high discharge but low pollutant concentration may deliver more of a pollutant to its receiving body than a stream with a higher pollutant concentration but lower discharge. It is the total amount of nutrients, suspended solids, and pathogens transported by the stream that is of greatest concern when considering the effects of these materials on downstream waterbodies.

Selected Physical and Chemical Parameter Concentrations
Table 4 presents results for physical and selected chemical parameters measured during the July 7, 2003 storm event.

Table 4. Selected physical and chemical parameter data collected from Five Lakes Watershed streams.

Stream Name	Site	Flow (cfs)	Temp (deg C)	DO (mg/l)	DO Sat (%)	pH
Little Elkhart Creek	1	2.3	22.3	6.1	70.9	7.8
Tributary to Witmer Lake	2	0.0	20.7	3.1	34.4	7.3
Tributary to Westler Lake	3	0.5	19.4	6.4	68.2	7.8
Oliver Lake outlet	4	2.5	26.0	6.5	80.2	7.9
J.J. Charles Drain	5	--	--	--	--	--

Temperature and pH values at all sites were below the maximum or within the range established for Indiana streams. The highest temperature was observed in the Oliver Lake outlet (26.0 ºC); high temperatures could be attributed to the lack of tall riparian vegetation throughout the wetland through which the stream flows. The lowest temperature (19.4 ºC) was measured in the Westler Lake tributary. This is likely due to sample collection occurring immediately after a rain event.

Dissolved oxygen (DO) concentrations varied from 3.1 mg/l to 6.5 mg/l. All streams except the Witmer Lake tributary contained dissolved oxygen concentrations which exceeded the Indiana state minimum of 5 mg/l, indicating that oxygen was sufficient to support aquatic life during storm flows at the remaining three tributaries. Dissolved oxygen concentrations at the Witmer Lake tributary were below the minimum concentration required to support warmwater aquatic life. This site is located approximately fifteen feet from Witmer Lake and water in the stream was at the lake level at the time of sampling. The low dissolved oxygen at the sites suggests decomposition and respiration processes were consuming available oxygen faster than oxygen could be diffused into the water. Additionally, oxygen was not entering the water via photosynthesis at this site as trees proved an extremely thick cover over the channel.

Since DO varies with temperature (cold water can hold more oxygen than warm water), it is also important to examine DO saturation values. DO saturation refers to the amount of oxygen dissolved in water compared to the total amount possible when equilibrium between the stream water and the atmosphere is maximized. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. Oversaturation occurs when in-stream processes add more oxygen to the water column than would be expected at a given temperature. DO saturation ranged from 34% in the Witmer Lake tributary to 80% in the Oliver Lake outlet. The low saturation in the Witmer Lake tributary is likely due to the two factors noted above: the consumption of oxygen during the decomposition of organic material in the stream and the relatively non-turbulent water limiting the entrainment of oxygen into the stream from the air. None of the sites experienced supersaturation during the storm event sampling.

Chemical and Bacterial Parameter Concentrations
Table 5 lists the chemical and bacterial concentration data for the Five Lakes inlets by site.

Table 5. Nutrient, sediment, and bacterial parameter data from the Five Lake watershed streams.

Stream	Site	NO_3-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	SRP (mg/l)	TP (mg/l)	TSS (mg/l)	*E. coli* (col/100ml)
Little Elkhart Creek	1	0.6	0.05*	0.8	0.05*	0.1	11	1,060
Tributary to Witmer Lake	2	0.1*	0.05*	1.3	0.05*	0.2	1*	1,840
Tributary to Westler Lake	3	3.7	0.05*	1.7	0.3	0.7	560	10,100
Oliver Lake outlet	4	0.3	0.05*	0.9	0.05*	0.05*	2	410
J.J. Charles Drain	5	--	--	--	--	--	--	--

*Method detection level.

Nitrate-nitrogen concentrations measured during storm flow conditions were relatively low at all sites except the Westler Lake tributary. Concentrations ranged from below the detection level (0.1 mg/l) in the Witmer Lake tributary to 3.7 mg/l in the Westler Lake tributary. Nitrate-nitrogen concentrations in the Witmer Lake tributary and the Oliver Lake outlet were at or lower than the USEPA recommended nitrate-nitrogen level (0.3 mg/l) for streams in the Aggregate Nutrient Ecoregion VII, which includes the Five Lakes Watershed (USEPA, 2000). The nitrate-nitrogen concentration measured in Little Elkhart Creek exceeded the USEPA recommended concentration, but was below the recommended criteria determined for Ohio streams (1.0 mg/l) to support healthy warmwater habitats for aquatic life (Ohio EPA, 1999). Concentrations at the Westler Lake tributary exceeded the USEPA recommended value and measured nearly five times the level at which impairment of aquatic biota occurs (Ohio EPA, 1999). Concentrations at all four sites were well below 10 mg/l, the concentration set by the Indiana Administrative Code for safe drinking water.

Ammonia-nitrogen concentrations were low at all four sites during the storm event sampling. All streams possessed ammonia-nitrogen concentrations below the laboratory detection limit (0.05 mg/l). None the sites contained ammonia-nitrogen concentrations in excess of the IAC standard.

In general, total Kjeldahl nitrogen concentrations were low to average in the inlets to the Five Lakes. TKN concentrations ranged from 0.8 mg/l in Little Elkhart Creek to 1.7 mg/l in the Westler Lake tributary. TKN levels exceeded USEPA recommended concentrations; however, these TKN concentrations are typical of Indiana streams.

In contrast to TKN concentrations, total phosphorus concentrations were elevated in most of the Five Lakes tributaries. Total phosphorus concentrations ranged from below the detection level (0.05 mg/l) in the Oliver Lake outlet to 0.7 mg/l in the Westler Lake tributary. Total phosphorus concentrations in Little Elkhart Creek, the Witmer Lake tributary, and the Westler Lake tributary exceeded recommended criteria for streams in Aggregate Nutrient Ecoregion VII. Additionally, these levels exceed the level found by Dodd et al. (1998) to mark the boundary between mesotrophic and eutrophic stream conditions, suggesting these systems are eutrophic. The total phosphorus concentration measured in the Westler Lake tributary exceeded the Ohio EPA's numeric total phosphorus criterion (0.28 mg/l) set to protect aquatic life. Furthermore, the high total phosphorus concentrations and resultant productivity in these tributaries may be altering the tributaries' biotic community structure and impairing aquatic life in the tributaries.

Total suspended solids concentrations were low in three of the four inlets during the storm event sampling. Higher overland flow velocities typically result in an increase in sediment particles in runoff. Additionally, greater streambank and stream bed erosion occurs during high flow. Therefore, higher concentrations of suspended solids are typically measured in storm flow samples. Concentrations ranged from below the detection level (1 mg/l) in the Witmer Lake tributary to 560 mg/l in the Westler Lake tributary. The TSS concentration measured in the Westler Lake tributary exceeded the concentration found to be deleterious to aquatic life (Waters, 1995).

All of the samples collected during the storm event exhibited *E. coli* concentrations above the state standard (235 colonies/100 ml) for grab samples. The samples collected from the Oliver Lake outlet possessed the lowest *E. coli* concentration (410 colonies/100 ml), while the sample from the Westler Lake tributary exhibited the highest *E. coli* concentration (10,100 colonies/100 ml). *E. coli* concentrations measured in three of the Five Lakes inlets were higher than most other streams in the state. White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 colonies/100 ml; the average *E. coli* concentrations measured in the Five Lakes inlets was 3,352 colonies/100 ml. High *E. coli* concentrations suggest the presence of other pathogens. These pathogens may impair the tributaries' biota and limit human use of the creeks.

Nutrient and Sediment Parameter Mass Loading
Table 6 lists the nutrient and sediment mass loading data in the Five Lakes inlets.

Table 6. Chemical and sediment loading data from the Five Lakes Watershed streams.

Stream	Site	NO_3-N Load (kg/d)	NH_3-N Load (kg/d)	TKN Load (kg/d)	SRP Load (kg/d)	TP Load (kg/d)	TSS Load (kg/d)
Little Elkhart Creek	1	0.11	bdl	0.16	bdl	0.02	2.15
Tributary to Witmer Lake	2	bdl	bdl	0.00	bdl	0.00	bdl
Tributary to Westler Lake	3	0.17	bdl	0.08	0.02	0.03	25.55
Oliver Lake outlet	4	0.06	bdl	0.19	bdl	bdl	0.43
J.J. Charles Drain	5	--	--	--	--	--	--

bdl=Below Detection Level

Making comparisons among sites using grab water quality samples is difficult since grab samples offer a picture of the stream at a singular point in time. There is no assurance that the grab samples are representative. Making comparisons among sites sampled during this study is difficult since sample collection did not occur under uniform circumstances despite the best efforts of biologists. Results (Table 6) suggest that the unnamed tributary to Westler Lake contributes more pollutants to the Five Lakes than the other tributaries. This is counterintuitive since Little Elkhart Creek has an extremely large watershed compared to other tributaries; therefore, one would expect Little Elkhart Creek to contribute more pollutants to the Five Lakes than the other tributaries. Previous studies support this concept and have shown Little Elkhart Creek to be the major contributor of pollutants to the Five Lakes (F.X. Browne, 1992). Given the unusual circumstances surrounding sample collection in this study, our grab samples may not be representative. It is important to note that the unnamed tributary to Westler Lake was not flowing when it was first examined. It was only found to be flowing following the 30-minute rain event and, even then, its discharge was only one-fifth of Little Elkhart Creek's discharge. Conversely, Little Elkhart Creek is a perennial stream, transporting pollutants to the Five Lakes on a continual basis. Although calculation of an annual pollutant load is beyond the scope of this study, it is likely that Little Elkhart Creek contributes a greater amount of pollutants on a yearly basis compared to the unnamed tributary to Westler Lake. Therefore, projects to improve water quality should be located on Little Elkhart Creek. However, results of our sampling suggest that the unnamed tributary to Westler Lake should be examined in the future to identify potential water quality improvement projects once management of pollutant inputs from Little Elkhart Creek has begun. Future watershed management planning efforts should target the unnamed tributary to Westler Lake and its watershed.

4.0 PROJECT REVIEW

4.1 GRADE CONTROL AND SEDIMENT TRAP CONSTRUCTION, LITTLE ELKHART CREEK, WITMER LAKE

4.1.1 Site Description and Alternatives

The Little Elkhart Creek project area is located on the northeast edge of Wolcottville within the structure of the Mill Pond (Figure 8). The project area includes the approximately 5-acre Mill Pond. (Appendix A contains photographs of the project site.) The Mill Pond is located entirely within property owned by Cliff Pettit.

Figure 8. Little Elkhart Creek project site.

Conditions within the vicinity of the project site mimic those observed throughout the Little Elkhart Creek Subwatershed. Soils nearest the Mill Pond are loams and sandy loams, as are a majority of the soils in the stream's watershed. Soils within the Mill Pond are predominantly clay loams and muck. The Little Elkhart Creek Subwatershed has a relatively high gradient, falling from nearly 1010 feet above mean sea level to 934 feet mean sea level within Wolcottville and 897 feet mean sea level at the stream's confluence with Witmer Lake.

Agricultural row crop and pasture land dominate land use within the Little Elkhart Creek Subwatershed, while emergent and scrub shrub wetlands bordered by row crop agricultural fields form the Mill Pond shoreline. Filamentous algae, curly-leaf pondweed (*Potamogeton crispus*), water lily (*Nymphaea* species), and duckweed (*Lemna* species) grow within the Mill Pond, while cattails (*Typha latifolia*), reed canary grass (*Phalaris arundinacea*), and blue vervain (*Verbena hastata*) vegetate the pond's shoreline. Agricultural fields border the scrub shrub wetland on the north side of the pond, while a narrow woodlot mixed with wooded wetlands and agricultural fields border the emergent wetland on the south side of the Mill Pond. Future plans for the 220 acres of agricultural fields to the north include the implementation of agricultural best management practices and enrollment in conservation programs to reduce sediment and sediment-attached pollutant loading to Little Elkhart Creek. The Lagrange County Natural Resources Conservation Service (NRCS) and Mr. Pettit are working together to develop conservation plans for the property (Mr. Pettit, personal communication).

Little Elkhart Creek remains hydrologically connected to its floodplain with the Mill Pond providing additional water storage capacity. Little Elkhart Creek does not appear to have been dredged or straightened in the past. Mill Pond construction in the early 1900's represents the only apparent channel modification along the lower portion of the stream. As water moves through the Mill Pond, flow is slowed causing sediment and sediment-attached pollutants to fall out of suspension and accumulate within the Mill Pond. Sampling conducted during 2000 indicated that the Mill Pond contained 1.5 to 2.5 feet of accumulated sediment with areas of greater depth located closer to the pond's outlet. Sediment samples collected concurrently with sediment accumulation measurements contained phosphorus concentrations of 950 mg/kg (Commonwealth Biomonitoring, 2001). Additionally, the structure which maintains the Mill Pond's pool elevation has fallen into disrepair and appears on the IDNR Division of Water's list of failed dams. As the structure continues to degrade, the risk of sediment and nutrient-laden water flowing downstream to Witmer Lake increases. During a high flow event, channel scour along the section of Little Elkhart Creek downstream of the Mill Pond could create a pulse of sediment and sediment-attached pollutants that would eventually reach Witmer Lake.

Alternatives for failed dam replacement and sediment control within the Mill Pond included: 1) replacement of the failed dam and hydrologic dredging, 2) grade control installation and sediment trap construction, and 3) taking no action. Both options 1 and 2 will achieve the desired goal of preventing the release of sediment and sediment-attached pollutants from the Mill Pond to Witmer Lake. Option 2 is the most cost effective solution of the two options. Additionally, the creation of a sediment trap within the Mill Pond will allow for sediment deposition to occur thereby reducing sediment and sediment-attached pollutant loading to Witmer Lake.

4.1.2 Easement and Land Availability Determination
One individual currently owns the parcel of land where the Little Elkhart Creek project is proposed. Presently, the property owner has no definite plans for the Mill Pond and surrounding properties, therefore the land is available for design and construction of the proposed project. An access and maintenance agreement is included with the design report produced concurrently with this report.

4.1.3 Preliminary Design and Conceptual Drawings
A grade control structure is proposed at the existing failed dam location (Figures 9 and 10). The structure is designed to maintain the current pool elevation. Grade control structures are constructed of glacial stone (Figure 10). The grade control structure will raise the bed of the channel at the current location of the failed dam to a level where the existing pool elevation is maintained. Fine sediment and sediment-attached pollutants will continue to be deposited in slower-flowing water upstream of the grade control. A temporary rock barrier will be constructed upstream of the failed dam structure. Following construction of the temporary barrier, the final the existing concrete structures will be moved and incorporated into the grade control structure. Removing these structures could resuspend flocculent sediment and sediment-attached pollutants; therefore, incorporating the existing structures into the grade control will limit the volume of sediments and sediment-attached pollutants transported downstream during project construction.

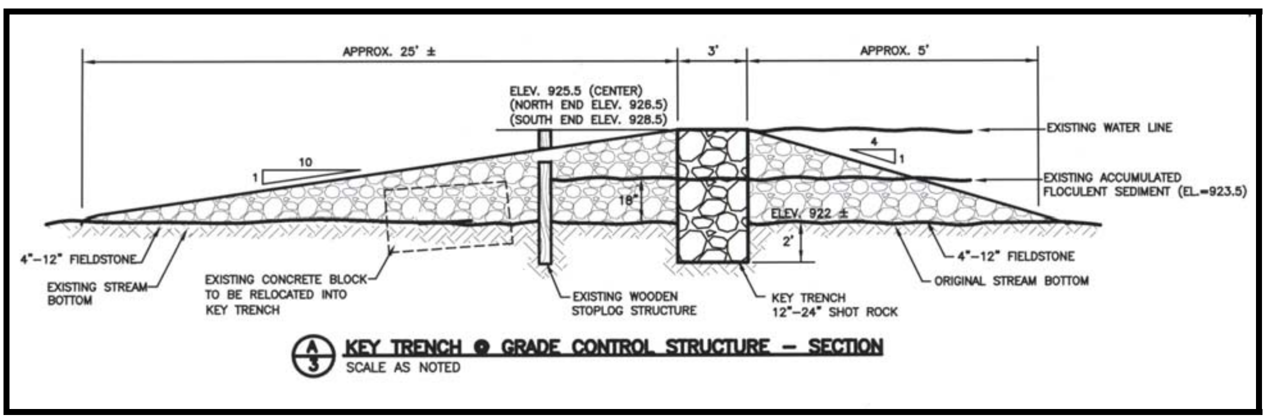

Figure 9. Grade control conceptual design, cross section.

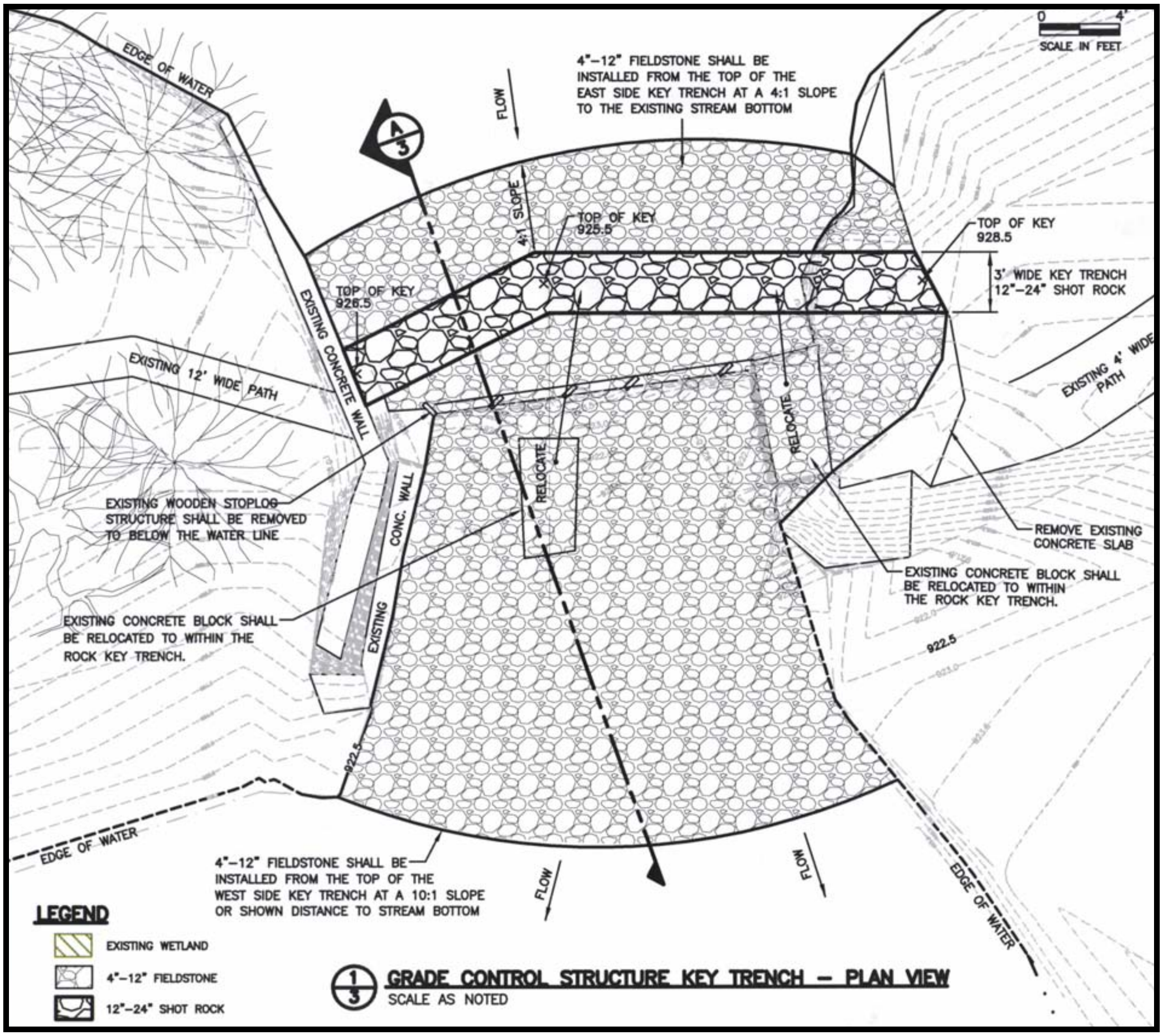

Figure 10. Grade control conceptual design, plan view.

Sediment trap construction within the Mill Pond will provide additional area for sediment and sediment-attached pollutant deposition (Figure 11). A sediment trap measuring approximately one-half acre will be constructed approximately 100 feet upstream of the dam along the northern shoreline of the Mill Pond. Existing sediment to a depth of approximately three and one-half feet will be removed using hydraulic dredging. Dredge material will be transported to a dewatering basin constructed in the agricultural fields north of the Mill Pond. Return water from the dewatering basin will flow around the berm constructed down the middle of the basin before being piped back to the Mill Pond.

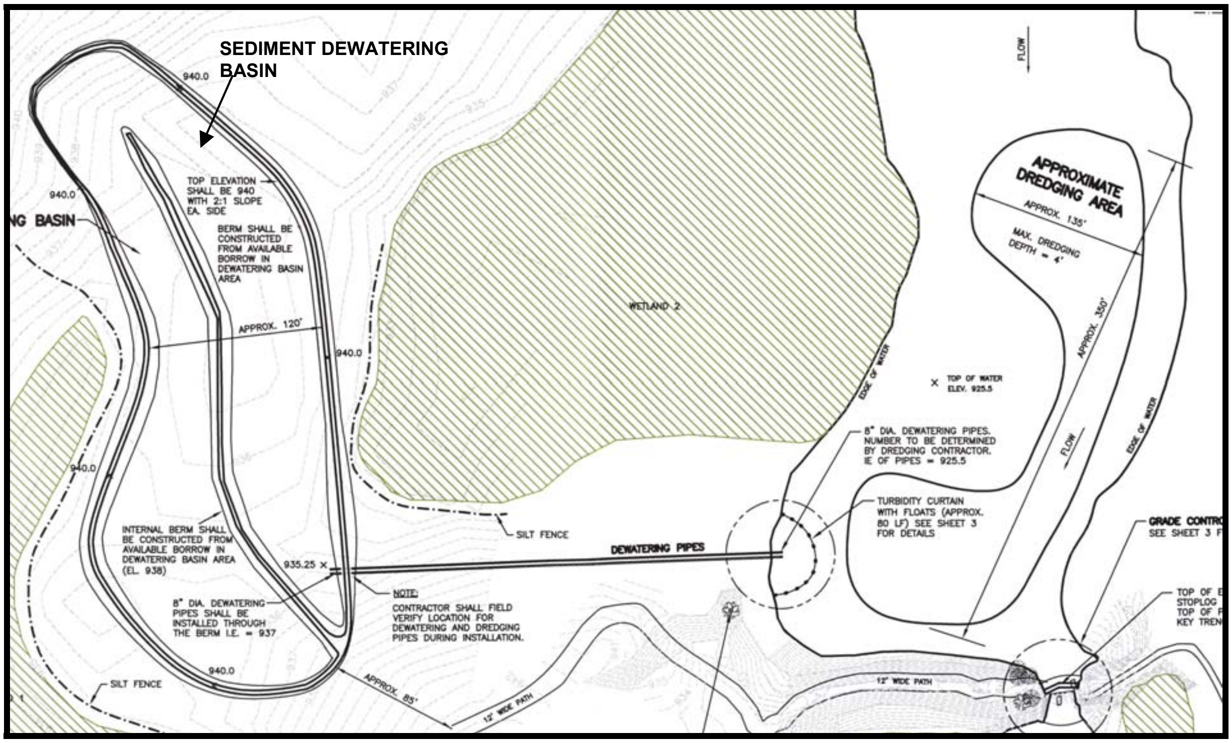

Figure 11. Sediment trap and sediment dewatering basin designs, plan view.

4.1.4 Permit Requirements

The proposed project will require a permit from the Lagrange County Drainage Board. An Indiana Department of Natural Resources construction in a floodway permit is also required because project construction will occur within the Little Elkhart Creek floodway. A Clean Water Act Section 401 Water Quality Certification from IDEM and a Section 404 Permit from the U.S. Army Corps of Engineers (USACOE) are required because Little Elkhart Creek is a "waters of the United States". Permit applications were submitted to the Lagrange County Surveyor's Office, IDEM, IDNR, and USACOE as part of this feasibility study. Final permits are included in the design report.

4.1.5 Landowner Agreements

The property owner has signed a letter supporting the project as conceptually designed (Appendix B).

4.1.6 Wetland Functional Assessment

The general locations and extent of four wetlands located within the vicinity of the project site were mapped during a field survey conducted December 24, 2003. Figure 12 shows the approximate locations of these wetland areas. Wetland 1 is located north of the proposed dewatering basin. The plant community of Wetland 1 is composed of box elder (*Acer negundo*), reed canary grass (*Phalaris arundinacea*), multiflora rose (*Rosa multiflora*), and willow (*Salix* species). Wetland 2 forms the northern shoreline of the Mill Pond extending north toward the proposed dewatering basin. Silky dogwood (*Cornus amomum*) and reed canary grass vegetate this wetland. Wetland 3 abuts the northern shoreline of Little Elkhart Creek downstream of the failed dam. Cottonwood (*Populus deltoides*) and gray dogwood (*Cornus racemosa*) are the predominant vegetation within this wetland. Wetland 4 is a seep wetland located south of Little Elkhart Creek, immediately south of Wetland 3. Sedges and other herbaceous plants vegetate this wetland.

Figure 12. Approximate wetland locations near the Mill Pond project site.

Wetland functions generally include: runoff filtration, water storage, groundwater recharge and discharge zones, and habitat provisions for flora and fauna. Because Little Elkhart Creek remains hydrologically connected to the floodplain, storm flows that overtop the banks of the creek spread out into the floodplain. Slowing of runoff in these areas decreases erosive forces downstream, allows for sedimentation of water-born particles, and offers nutrient filtration functions. Although these wetlands probably offer little long-term water storage capacity, they do serve as groundwater recharge and discharge zones and provide valuable wildlife habitat. Design and construction of the proposed projects will avoid impact to these wetland areas.

4.1.7 Biological and Habitat Integrity Survey

On September 5, 2003, JFNew surveyed the fish community of Little Elkhart Creek by backpack electrofishing for a sample distance of 450 feet and a sample time of 3,051 seconds. Sample collected occurred downstream of the project site at Little Elkhart Creek's intersection with State Road 9. Fish collected during the survey were used to calculate an Index of Biotic Integrity (IBI). Karr (1981) first developed the IBI for evaluating biotic integrity of fish communities. Simon (1997) further modified and calibrated the IBI for use in the Northern Indiana Till Plain of Indiana. Biological integrity is defined as, "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region" (Karr and Dudley, 1981).

The IBI is designed to assess biotic integrity directly through twelve attributes of fish communities in streams. These attributes fall into such categories as species richness and composition, trophic composition, and fish abundance and condition. After data from sampling sites have been collected, values for the twelve metrics are compared with their corresponding expected values (Simon and Dufour, 1997) and a rating of 1, 3, or 5 is assigned to each metric based on whether it deviates strongly from, deviates somewhat from, or closely approximates the expected values. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60 (Table 7).

Table 7. Attributes of Index of Biotic Integrity classification.

IBI	Integrity Class	Attributes
58-60	Excellent	Comparable to the best situation without human disturbance.
48-52	Good	Species richness somewhat below expectations.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists.
12-22	Very Poor	Few fish present. Mostly introduced or tolerant forms.
0	No Fish	Repeat sampling finds no fish.

Source: Simon, 1997.

Table 8 contains data for the calculation of the IBI for Little Elkhart Creek. Field datasheets are included in Appendix C. The IBI score calculated for Little Elkhart Creek places the fish community between the "poor" and "fair" integrity classes. Three of the metrics received a rating of "1" indicating that they deviated strongly from ecoregion expectations. The low number of sunfish species is likely due to the lack of deep pools within the sampling reach, a habitat feature necessary for prospering riverine sunfish populations. Carnivores were represented by two species, spotted bass and grass pickerel. The low number of these individuals may also be due to the lack of deep pools. DELT anomalies were most evident in the yellow bullhead population. Lesions were common on the bullheads' ventral surfaces. Other metrics received average (3) or good (5) ratings.

Table 8. Data from the biotic assessment of Little Elkhart Creek as sampled on September 5, 2003.

Metric	# or %	Score
# of species	16	5
# of darter species	2	3
# of sunfish species	1	1
# of sucker species	3	5
# of sensitive species	3	3
% tolerant individuals	42	3
% omnivorous individuals	18	5
% insectivorous individuals	77	5
% carnivores	4	1
Catch per unit effort	137	3
% simple lithophilic individuals	27	3
% DELT individuals	4	1
IBI Score		**38**
Integrity class		**POOR to FAIR**

DMS = darter, madtom, sculpin
DELT = deformities, erosion, lesions, tumors

Habitat was also evaluated on September 5, 2003 using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989 and 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates; amount and quality of in-stream cover; channel morphology; extent and quality of riparian vegetation; pool, run, and riffle development and quality; and gradient are some of the metrics used to determine the QHEI score. Scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999). In Indiana, scores greater than 64 suggest that the stream meets its aquatic life use designation.

QHEI metric scores are listed in Table 9 with datasheets in Appendix C. The sampling reach received a QHEI score of 75 indicating the potential of supporting an exceptional warmwater fauna and meeting its aquatic life use designation. The riparian and pool scores were the only metrics receiving poor scores (only six of ten points and seven of a possible twelve points, respectively) due to the narrowness of the riparian zone and relative lack of deep pool habitat.

Table 9. QHEI scores for the Little Elkhart Creek assessment reach as sampled on September 5, 2003.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	20	20	20	10	12	8	10	**100**
Little Elkhart Creek	16	15	18	6	7	6	8	**75**

4.1.8 Environmental Impact Assessment

Environmental considerations relevant to the proposed project include: wetlands; endangered, threatened, and rare (ETR) species; water quality; flooding; stream habitat; and stream biota. Replacement of the failed dam structure and sediment trap construction within the Mill Pond can proceed with minimal negative impact to environmental factors. Although an endangered species survey was not conducted, the dominant plant species documented in the Little Elkhart Creek project area did not include any state-listed species. Additionally, the DNR Division of Nature Preserves (DNP) Natural Heritage database does not contain documentation of any ETR plant or animal species within a two square mile radius of the Mill Pond.

Since the proposed project will not impact the wetlands near Little Elkhart Creek, it is assumed that these areas will continue to function as they have historically. The wetlands adjacent to the Mill Pond are riverine wetlands which are typically subjected to periodic inundation; species located in the riparian area are already adapted to the periodic flooding, so any flooding that occurs following grade control construction should not negatively impact the existing vegetation. The proposed grade control construction project will have little impact on flooding. The grade control structure will be sized such that the current pool elevation is maintained. Neither increasing the Mill Pond's size, which could flood areas higher in the watershed, nor decreasing the Mill Pond's size, which could flood areas lower in the watershed, is planned during any portion of the project. Since periodic inundation or flooding of the riverine wetland adjacent to the Mill Pond currently occurs, it is likely that this natural water storage regime will continue. Additionally, the grade control structure will stabilize the Mill Pond, preventing a potential pulse of sediment and nutrient-laden water from moving downstream if the failed dam further disintegrates.

The stone used to build the grade control structure will offer aquatic biota in-stream habitat both within and downstream of the Mill Pond. Sediment trap construction should lead to improved water quality in the stream and in Witmer Lake as sediment and sediment-attached pollutants fall out of suspension within the Mill Pond, thereby reducing sediment and sediment-attached pollutant loads to Little Elkhart Creek and, ultimately, Witmer Lake. During construction, the excavation and modification of the failed dam structure and resultant localized disturbance of the riparian zone has the potential to impair both water quality and habitat temporarily. A temporary barrier will be constructed around half of the grade control structure with the grade control to be built inside the barrier; once construction of half of the grade control is complete, the barrier will be moved to enclose the other half of the channel. This barrier will reduce the flow of sediment and sediment-attached pollutants downstream to Witmer Lake. Over the longterm, the grade control and sediment trap will result in more stable habitat. Rock added for toe stabilization will provide additional in-stream habitat. Downstream of the Mill Pond, biotic integrity was rated as fair to poor during the fall of 2003 assessment of the fish community. This assessment suggests that the stream has been previously impacted by anthropogenic factors. Fish communities of the type observed in Little Elkhart Creek are dominated by tolerant species adapted to human-induced environmental stresses. Limited numbers of sensitive species and lack of ETR species suggests that the fish community has already adjusted to existing environmental stresses and relatively poor water quality. The fish community will likely be minimally impacted by project construction; any impacts that do occur would be temporary.

4.1.9 Unusual Physical and Social Costs

Unusual physical and social costs associated with design and construction of this project include: avoiding wetland areas, attaining access to the project site, avoiding transport of sediment and sediment-attached pollutants downstream during construction, and removing remaining failed dam structures from the stream channel. Wetlands are located to both the north and south of where grade control structure will be installed. Grade control construction will avoid adjacent wetlands and construction material will be stored away from these wetlands. Wetlands are also located adjacent to the Mill Pond's northern shoreline and to the north of the sediment dewatering basin. Placement of the dewatering basin is such that wetlands are avoided during both basin construction and use and the placement of dewatering pipes, which return water to Little Elkhart Creek. The site will be accessed through an existing agricultural field, which requires that the project be constructed following fall harvest. Construction vehicles will utilize an existing agricultural access road, which needs to be cleared prior to the beginning of the project. The access road is located away from existing wetlands; using this existing road will minimize impacts to adjacent agricultural fields. Both grade control and the sediment basin construction will occur in-stream, requiring the usage of a temporary barrier to limit the transport of sediment and sediment-attached pollutants downstream. Portions of the remaining failed dam structure will be incorporated into the newly constructed grade control. However, some of portions of the dam will need to be moved from their existing positions to ensure that the structure of the grade control conforms to the project design. Any movement of the existing failed dam structure will occur within the temporary barrier to minimize the transport of sediment and sediment-attached pollutants downstream.

4.1.10 Opinions of Probable Cost

The opinion of probable cost is $73,750 for grade control and sediment trap construction (Table 10).

Table 10. Opinion of probable cost for grade control and sediment trap construction at the Mill Pond project site.

Item	Cost	Total
Mobilization/Demobilization		**$10,000**
Dewatering basin construction including silt fence installation	$3,000	
Grade control	$2,000	
Hydraulic dredging (Sediment trap creation)	$5,000	
Construction Activities		**$57,700**
Construction of sediment dewatering basin	$7,500	
Leveling of sediment dewatering basin	$7,500	
Installation of grade control	$15,000	
Hydraulic dredging of the Mill Pond	$27,700	
Contract Administration/Construction Supervision		**$6,050**
TOTAL		**$73,750**

4.2 LIVESTOCK FENCING ALONG J.J. CHARLES DRAIN, HACKENBURG LAKE

4.2.1 Site Description and Alternatives

The J.J. Charles Drain Subwatershed drains 879 acres (356 ha or 1.4 square miles) of largely agricultural row crop, pasture land, and wetland to the northwest of Hackenburg Lake (Figure 13). J.J. Charles Drain is a legal drain meaning that the Lagrange County Surveyor's Office can collect ditch assessment fees in order to maintain proper drainage. The reach examined during this feasibility study included approximately 500 lineal feet of the mainstem of J.J. Charles Drain located entirely within property owned by Jerry and Rosemary Yoder. (Appendix A contains site photographs for the livestock fencing project site.)

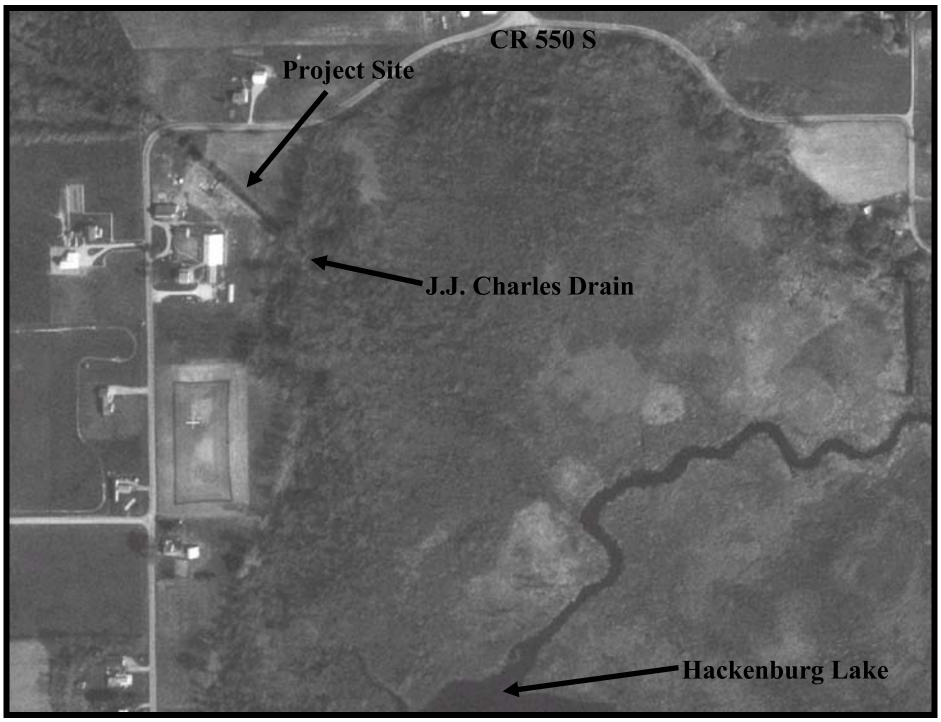

Figure 13. J.J. Charles Drain project site.

Physical characteristics observed at the project site are typical of the J.J. Charles Drain Subwatershed. Soils bordering the stream at the project are loams and sandy loams, as they are throughout the watershed. The streambanks are shallow throughout the project site measuring approximately three to eight feet in height. The watershed slopes from approximately 915 feet above mean sea level near the headwaters to 897 feet above mean sea level at Hackenburg Lake. The land surrounding the project area is grazed pasture land. Row crop agriculture and pastureland is present upstream of the project site, while emergent and forested wetlands exist between the project site and Hackenburg Lake.

Livestock grazine in riparian areas are directly and indirectly responsible for the loss of density and diversity of riparian vegetation, a decline in water quality, and modification of the aquatic community structure. Unrestricted livestock trample riparian vegetation, which results in the conversion of densely-vegetated riparian areas to grass monocultures (Kimball and Savage, 1977). Woody vegetation and deep-rooted perennial herbaceous species are quickly replaced by shallow-rooted, annual plants, which provide lower nutritional value to grazing livestock and less streambank protection than their perennial counterparts often destabilizing streambanks (Platts, 1991). Sloughing streambanks combined with exposed sediments contribute fine sediments from the streambank to the stream channel (Armour, 1977). Erosive action by wind and water causes rich topsoil, sediment, and sediment-attached pollutants to move from the streambank into the water causing a decline in the water quality of the receiving stream (Platts, 1991). Poor riparian vegetation density and diversity, high fecal coliform levels, high sediment and nutrient loading rates, and in-stream sedimentation combine to degrade water quality and habitat conditions. Typically, tolerant, less-specialized aquatic macroinvertebrates predominate in streams where livestock grazing is prevalent (Phillips and Simpson, 2003). Continuous livestock grazing causes a decline in riparian and floodplain species density and diversity, increases channel erosion, alters instream productivity, increases sediment movement, increases stream turbidity, decreases dissolved oxygen, and modifies food web structure (Braun et al., 2003).

Alternatives for channel restoration in the study reach included the installation of fencing to restrict livestock access to the stream, streambank stabilization, and no action. Because the landowner is interested in maintaining the area as pastureland, restricting livestock access to the stream is the most cost-effective alternative. Fencing the livestock from the stream channel will reduce streambank trampling and nutrient and pathogen loading to the stream. The native plant community should revegetate the riparian zone once the livestock are fenced from the area.

4.2.2 Easement and Land Availability Determination

One individual currently owns the parcel of land where the livestock fencing project is proposed. Presently, the property owner plans to continue to graze livestock in areas away from the stream but will provide the livestock with an alternate water source.

4.2.3 Preliminary Design and Conceptual Drawings

The livestock fencing project along J.J. Charles Drain will consist of the installation of 915 lineal feet of new fence, one new gate, and approximately 45 evergreen trees. Previously grazed streambanks will be seeded with warm season grasses (Figure 14). New fence will be installed on the west side of J.J. Charles Drain from County Road 525 South to the existing culvert on the Yoder property. New fence will be installed across the culvert on both the north and south sides of the culvert structure. A new gate will be installed at the northeast corner of the culvert structure connecting the new fencing along the north edge of the culvert with existing fence to the east of the drain and along the northern property line thereby creating a small, triangular pasture. The installation of new fence southeast of the culvert structure will connect with the existing gate on the east side of the culvert and existing fence along the perimeter of the eastern pasture to exclude livestock from the drain. New fence will be installed between an existing driveway that parallels the drain and the south bank of J.J. Charles Drain. Evergreen trees will be installed between the driveway and the new fence. Because the streambanks will no longer be grazed, warm season grasses will be seeded into the existing vegetation along the banks. The seed will assist in the revegetation and stabilization of the streambanks.

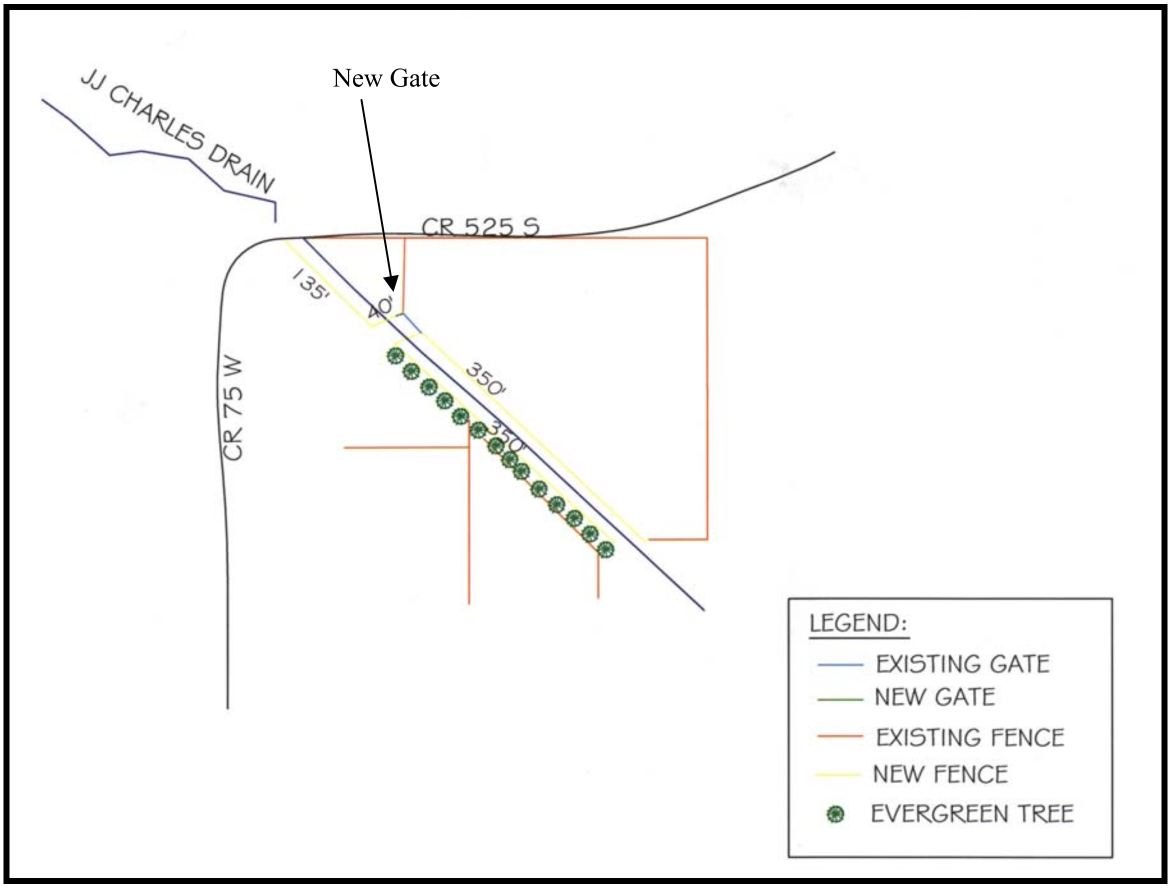

Figure 14. Livestock fencing project plan view.

4.2.4 Permit Requirements
No permits are required for this project.

4.2.5 Landowner Agreements
Mr. Yoder has signed a letter supporting the project as conceptually designed (Appendix B).

4.2.6 Wetland Functional Assessment
No wetlands lie in the project site.

4.2.7 Biological and Habitat Integrity Survey
Water within the stream channel was ponded in low spots during normal low flow conditions. JFNew biologists did not observe flow in the stream immediately following a large storm event. Available methods for evaluating a stream community's biological integrity require that the stream to be assessed is perennial. Because water does not flow through the J.J. Charles Drain, the streams biological community could not be assessed using commonly accepted methods.

4.2.8 Environmental Impact Assessment
Environmental considerations relevant to the proposed project include: wetlands; endangered, threatened, and rare (ETR) species; water quality; flooding; stream habitat; and stream biota. The installation of fencing along J.J. Charles Drain can proceed with minimal impact to environmental factors. Although an endangered species survey was not conducted, the dominant

plant species documented in the J.J. Charles Drain project area did not include any state-listed species. Additionally, the DNR Division of Nature Preserves Natural Heritage database does not contain documentation of any ETR plant species in the J.J. Charles Drain Subwatershed. Because no wetlands exist within or adjacent to the project site, there will not be any wetland impacts associated with the project. No structures will be installed within the stream channel; therefore, there will not be any impact to water levels or flooding. Restricting livestock access to the stream channel and revegetating the streambanks with warm season grasses will likely reduce the flow of sediment and sediment-attached pollutants from the pasture to the stream channel. Restricting livestock access will reduce nutrient and pathogen inputs to the stream from direct application, which will result in reduced nutrient and pathogen loading to Hackenburg Lake. Grasses will stabilize the streambank and intercept the flow of sediments and nutrients from the adjacent pasture. The DNR DNP database does not contain documentation of any ETR fish species in the stream. Although a biotic assessment was not completed as part of this study, it is likely that fencing livestock from the stream will improve instream conditions, thereby reducing human-induced stresses to the biotic community. Since the project will occur outside of the stream channel, the fish community will likely not be impacted by project construction.

4.2.9 Unusual Physical and Social Costs

There are no unusual physical and social costs associated with this project.

4.2.10 Opinions of Probable Cost and Proposed Time Line

The opinion of probable cost is $2,420 for livestock fencing and subsequent seeding in the J.J. Charles Drain project site (Table 11).

Table 11. Opinion of probable cost for livestock fencing and seeding along J.J. Charles Drain.

Item	Cost	Unit	Number	Total
Fence	$1.45	feet	915	$1,326
Gate	$60	each	1	$60
Evergreen trees	$10	each	45	$450
Seeding	$100	each	1	$100
Construction contingency	25%	each	1	$484
Total				**$2,420**

The recommended project timeline is based on LARE grant funding cycles. It is recommended the FLCA apply for design-build LARE funding in early 2004, contract out the construction of this project in late 2004, and complete construction in early 2005 at the latest.

4.3 PHOSPHORUS LOAD REDUCTION, WITMER LAKE

4.3.1 Site Description and Alternatives

The Witmer Lake tributary project site is located on the south side of Witmer Lake, south of County Road 765 South (Figure 1). The small tributary drains a relatively small watershed measuring approximately 595 acres (240 ha) from its headwaters to its mouth. The project site consists of the lower portion and mouth of the tributary which lies within a 43-acre (17.4-ha) parcel owned by Dan Yoder (Figure 15).

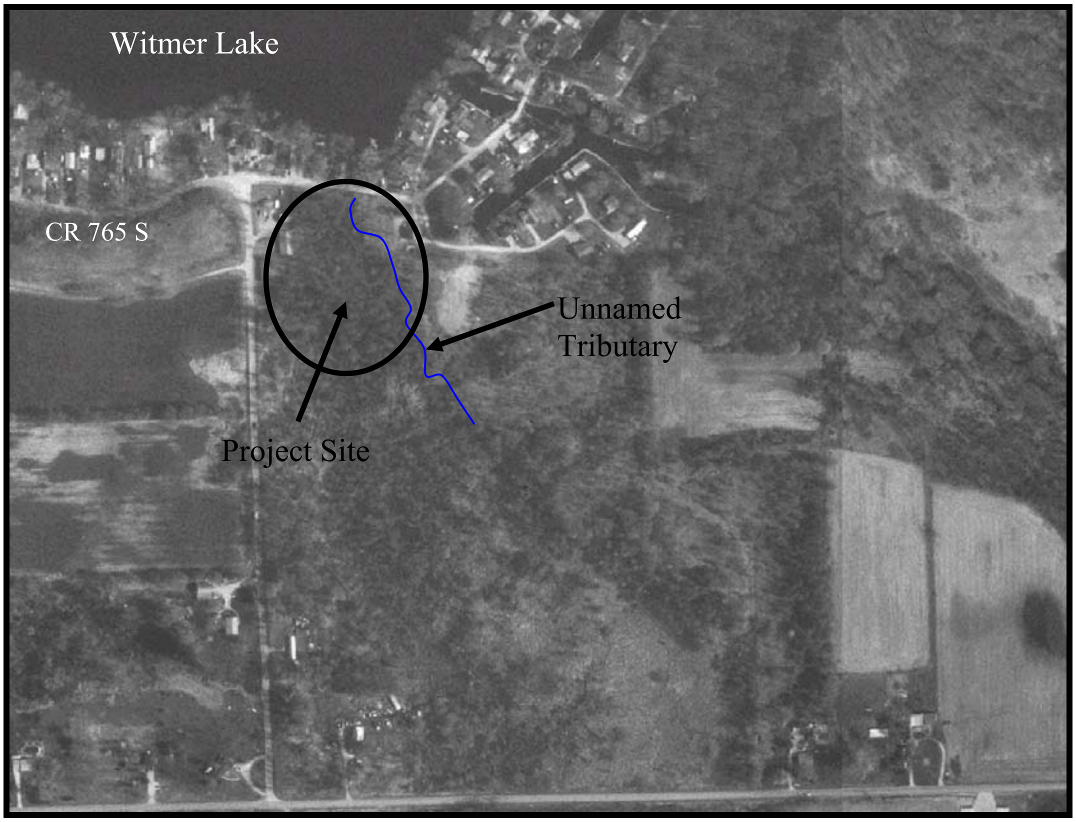

Figure 15. Witmer Lake tributary project site.

Originating in a wetland, a portion of the unnamed tributary had been excavated in the past to enhance the drainage of the wetland into Witmer Lake. However, a forested mature wetland remains intact adjacent to the stream until the road crossing at County Road 765 South. The wetland is a mixture of emergent, scrub shrub, and forested habitat extending over approximately 52 acres (21 ha) from just south of County Road 765 South to south of County Line Road. Cattails and reed canary grass dominate the southern portion of the wetland bordering County Line Road. Wetland vegetation gradually transitions from emergent herbaceous vegetation to woody species including silver maple (*Acer saccharinum*), elm (*Ulmus* species), and swamp white oak (*Quercus bicolor*) with a bare ground understory. The mature wetland was presumed to be exporting high concentrations of nutrients according to sampling conducted in 1990 (F.X. Browne, 1992). Commonwealth Biomonitoring estimated that, in 1991, the tributary accounted for 17% of the total phosphorus load entering Witmer Lake. However, some question remains as to whether the samples were taken in actual drainage from the tributary or in an area that had already mixed with lake water, thereby possibly representing actual lake water quality instead of stream water.

Alternatives considered for phosphorus load reduction at the project site included constructing a sediment basin within or adjacent to the stream channel; planting wetland plants in the stream channel upstream of County Road 765 South to filter duckweed, leaves, and other pollutants; and thinning or removing a narrow band of silver maples adjacent to the tributary. Installing a sediment trap was not considered to be feasible for various reasons. First, the project would not likely be ecologically justifiable. Constructing a sediment trap either in-stream or in the adjacent wetland would damage, at least temporarily, the tributary's wetland corridor, impairing the wetland's ability to function. Additionally, sediment traps have good removal efficiencies for particulates (and any nutrients attached to those particulates) and poor removal efficiencies for dissolved nutrients. Wetlands similarly have good removal efficiencies for particulates and poorer removal efficiencies for dissolved nutrients. In fact, wetlands often serve as sources of dissolved phosphorus (Mitsch, 1993). Thus, it is likely that the wetlands adjacent to the tributary likely remove most of the particulate pollutants reaching the stream and may export dissolved phosphorus. An in-line sediment trap would not be capable of removing dissolved phosphorus to the level that would justify the impact to the surrounding wetland habitat that would occur during construction. Finally, the property owner was not willing to approve construction of a sediment trap. For these reasons, construction of a sediment trap in the project area was considering infeasible.

The second alternative, planting wetland vegetation in the tributary channel upstream of County Road 765 South, was considered infeasible as well. While the wetland plants would not be very efficient in the removal of dissolved phosphorus from the water column, the plants would trap duckweed and algae, preventing these from floating to the lake. This would indirectly limit phosphorus loading to the lake and also increase the aesthetic value of the lake. The property owner was not willing to approve this alternative.

The third option, removing selected silver maples from the edge of the wetland adjacent to the stream, was consider feasible but is not recommended at this time. The alternative would involve removing silver maples from a 25-foot swath adjacent to the tributary to encourage the growth of herbaceous vegetation. The herbaceous vegetation may be more effective than the silver maples in trapping pollutants, particularly leaves, as the pollutants move from the wetland to the tributary. The land owner found this alternative agreeable. However, there is no available research demonstrating that herbaceous wetland vegetation is more efficient in removing or preventing pollutants from reaching a stream adjacent to a wetland than woody vegetation. Consequently, this alternative was considered feasible but not recommended at this time.

4.3.2 Easement and Land Availability Determination

One individual currently owns the parcel of land where the phosphorus load reduction project would occur. Presently, the property owner has no definite plans for the parcel, except for recreation.

4.3.3 Preliminary Design and Conceptual Drawings

No project alternative is both feasible and recommended at this time, so preliminary designs or conceptual drawings were not developed at this time.

4.3.4 Permit Requirements

The stream is not a legal drain; therefore, a permit from the Lagrange County Drainage Board is not required for work in this drain. Permits from the Indiana Department of Natural Resources, the Indiana Department of Environmental Management, and the U.S. Army Corps of Engineers would be required for any project that involves the placement of fill material, excavation of wetland habitat, or mechanical removal of trees.

4.3.5 Landowner Agreements

Mr. Yoder is considering the options for treating the phosphorus problem at this drain; however, no projects are considered feasible or recommended at this point. Consequently, no landowner agreements were developed.

4.3.6 Wetland Functional Assessment

Wetlands border both sides of the unnamed tributary and form nearly 10% of the tributary's watershed. Figure 16 shows the U.S. Fish and Wildlife Service National Wetland Inventory map for the project area's vicinity. The plant community of the wetland within the project site is predominantly silver maple, but also contains swamp white oak and elm. Wetland functions generally include: runoff filtration, water storage, groundwater recharge and discharge zones, and habitat for flora and fauna. No project is recommended at this point so there is no expected impact to any of these wetland functions.

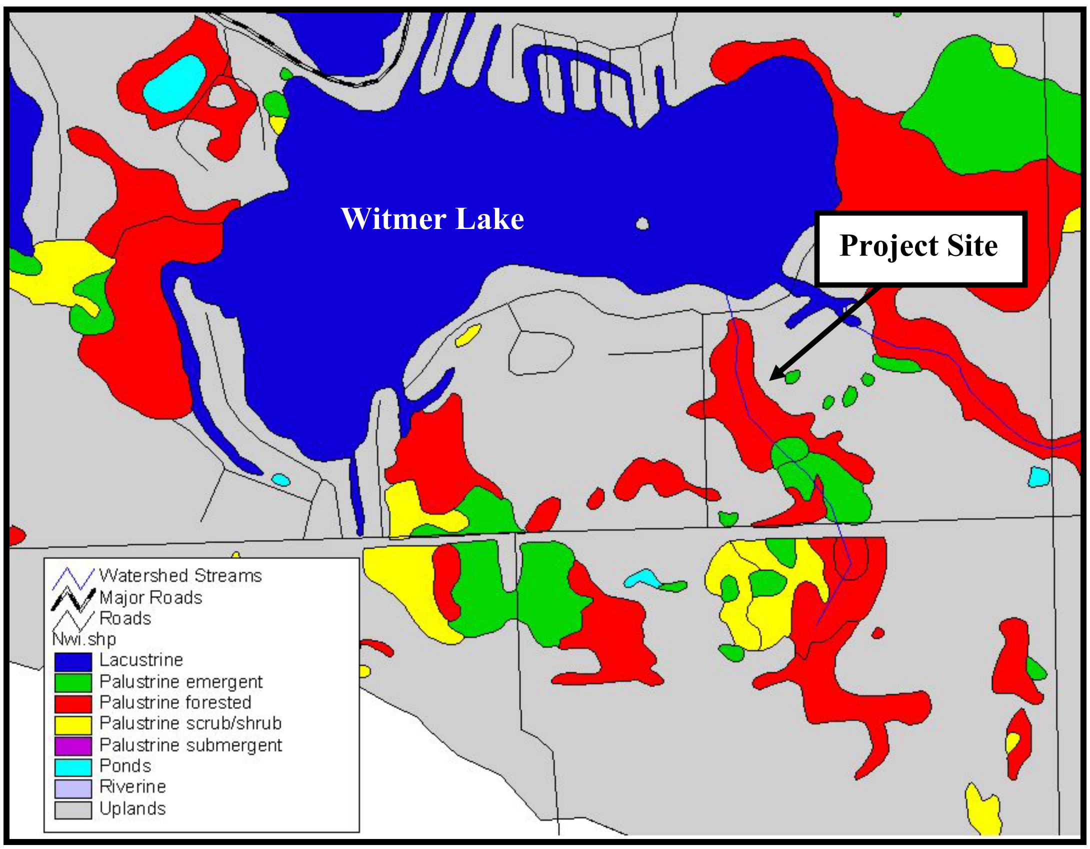

Figure 16. National Wetlands Inventory map of the phosphorus load reduction project area.

4.3.7 Biological and Habitat Integrity Survey

The biological and habitat integrity of the tributary was not assessed during the course of this study since no project is recommended at this time. JFNew biologists did not observe any fish in the stream during numerous site visits.

4.3.8 Environmental Impact Assessment
No project is recommended at this time, therefore no environmental impact assessment was completed of the project site.

4.3.9 Unusual Physical and Social Costs
No project is recommended at this time.

4.3.10 Opinions of Probable Cost
No project is recommended at this time.

5.0 RECOMMENDATIONS

1) Apply for LARE grant funding in 2004 for construction of the sediment trap and grade control structure along Little Elkhart Creek. Begin construction of the project in the Fall of 2004 following the crop removal.

2) Apply for LARE grant funding in 2004 for livestock fencing. Construction of the fence and tree planting can occur in the fall of 2004.

3) Pursue project recommendations from the Watershed Management Plan that is currently being developed.

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APPENDIX A:

PROJECT SITE PHOTOGRAPHS

Site Photographs-Existing Structure
Grade Control/Sediment Trap Installation
Pettit Property
Five Lakes Feasibility-Design Study

Storm Flow

Base Flow

Site Photographs-Mill Pond
Grade Control/Sediment Trap Installation
Pettit Property
Five Lakes Feasibility-Design Study

Site Photographs
Livestock Fencing
J. Yoder Property
Five Lakes Feasibility-Design Study

Site Photographs
Sediment and Sediment Attached Pollutant Load Reduction Project
D. Yoder Property
Five Lakes Feasibility-Design Study

APPENDIX B:

LANDOWNER COMMUNICATION

Landowner communication is not included with the electronic version of this report. Copies of the pertinent communication can be obtained from the Indiana Department of Natural Resources Division of Fish and Wildlife Lake and River Enhancement Program Office.

APPENDIX C:

BIOTIC ASSESSMENT FIELD DATA SHEETS

STREAM: Little Elkhart Creek **LOCATION:** State Road 9 **DATE:** 9/5/2003 **QHEI SCORE** 75

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 16

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[ ]	[X]	GRAVEL(7)	X	X
[ ]	[ ]	BOULDER(9)		X	[X]	[ ]	SAND(6)	X	X
[ ]	[ ]	COBBLE(8)		X	[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)	X		[ ]	[ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [X] >4(2) [ ] <4(0)

SUBSTRATE ORIGIN (all)

[ ]	LIMESTONE(1)	[ ]	RIP/RAP(0)
[X]	TILLS(1)	[ ]	HARDPAN(0)
[ ]	SANDSTONE(0)		
[ ]	SHALE(-1)		
[ ]	COAL FINES(-2)		

SILT COVER (one)

[ ]	SILT-HEAVY(-2)	[ ]	SILT-MOD(-1)
[X]	SILT-NORM(0)	[ ]	SILT-FREE(1)

Extent of Embeddedness (check one)

[ ]	EXTENSIVE(-2)	[ ]	MODERATE(-1)
[X]	LOW(0)	[ ]	NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS:

2) INSTREAM COVER: **COVER SCORE** 15

TYPE (Check all that apply)

[X]	UNDERCUT BANKS(1)	[ ]	DEEP POOLS(2)	[ ]	OXBOWS(1)
[X]	OVERHANGING VEGETATION(1)	[ ]	ROOTWADS(1)	[X]	AQUATIC MACROPHYTES(1)
[X]	SHALLOWS (IN SLOW WATER)(1)	[X]	BOULDERS(1)	[X]	LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

- [X] EXTENSIVE >75%(11)
- [X] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS:

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 18

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
[X] HIGH(4)	[ ] EXCELLENT(7)	[X] NONE(6)	[X] HIGH(3)
[X] MODERATE(3)	[X] GOOD(5)	[ ] RECOVERED(4)	[ ] MODERATE(2)
[ ] LOW(2)	[ ] FAIR(3)	[ ] RECOVERING(3)	[ ] LOW(1)
[ ] NONE(1)	[ ] POOR(1)	[ ] RECENT OR NO RECOVERY(1)	

MODIFICATION/OTHER

[ ] SNAGGING	[ ] IMPOUND
[ ] RELOCATION	[ ] ISLAND
[X] CANOPY REMOVAL	[ ] LEVEED
[ ] DREDGING	[ ] BANK SHAPING
[ ] ONE SIDE CHANNEL MODIFICATION	

COMMENTS:

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 6

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[ ]	WIDE >150 ft.(4)
[ ]	[ ]	MODERATE 30-150 ft.(3)
[ ]	[X]	NARROW 15-30 ft.(2)
[X]	[ ]	VERY NARROW 3-15 ft.(1)
[X]	[X]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[X]	[X]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[X]	[X]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[X]	[X]	NONE OR LITTLE(3)
[ ]	[ ]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS:

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 7

MAX.DEPTH (Check 1)

- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [X] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)

- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [X] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

[ ] TORRENTIAL(-1)	[X] EDDIES(1)
[X] FAST(1)	[ ] INTERSTITIAL(-1)
[X] MODERATE(1)	[ ] INTERMITTENT(-2)
[X] SLOW(1)	

COMMENTS:

RIFFLE SCORE 6

RIFFLE/RUN DEPTH

- [X] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [ ] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE

- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [X] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS

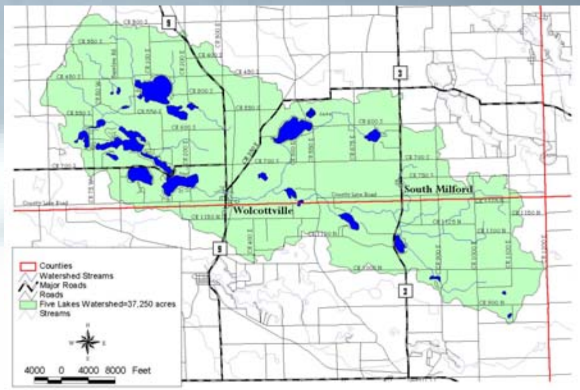
[ ] EXTENSIVE(-1)	[ ] NONE(2)
[X] MODERATE(0)	[ ] NO RIFFLE(0)
[X] LOW(1)	

COMMENTS:

6) GRADIENT (FEET/MILE): 22 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Understanding Your Watershed:

- The Five Lakes watershed encompasses approximately 37,250 acres in Lagrange and Noble Counties.



- The Five Lakes watershed forms the headwaters of the North Branch Elkhart River Basin.

- Land use in the watershed is mostly agricultural:

Row Crop	59.8%	Pasture	14.5%
Forest	10.9%	Wetland	7.6%
Open Water	5.9%	Urban	1.3%

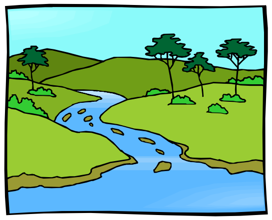
- A variety of groups have completed water quality, fisheries, and watershed management studies and projects within the Five Lakes watershed including:
  - ★Purdue University
  - ★Indiana University
  - ★IDNR, Division of Fish and Wildlife
  - ★IDNR, Division of Soil Conservation
  - ★IDNR, Division of Water
  - ★US Environmental Protection Agency
  - ★IDEM, Clean Lakes Program
  - ★Lagrange County Health Department
  - ★Lagrange County SWCD

For additional information on how to keep your lake and watershed clean and healthy contact:

Lake and River Enhancement Program
Indiana Department of Natural Resources
(IDNR) Division of Fish and Wildlife
402 West Washington Street Room 273
Indianapolis, Indiana 46204
(317) 233-3871

Five Lakes Conservation Association
Wolcottville, Indiana 46795

Lagrange County SWCD
910 South Detroit Street
Lagrange, Indiana 46761
(260) 463-3471 x3



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JFNew
708 Roosevelt Road
Walkerton, Indiana 46574
(574) 586-3400

If you have any questions regarding the study or pamphlet, please contact JFNew.

Five Lakes Engineering Feasibility/Design Study Lagrange and Noble Counties

The Five Lakes Engineering Feasibility/ Design Study is a multi-phase study that included the examination of the lakes' inlet water quality, determination of the feasibility of three potential water quality improvement projects, and the design of one of those projects. The three projects are installing fencing along J.J. Charles Drain to restrict livestock access to the drain, altering an existing wetland to reduce the nutrient load in an unnamed tributary to Witmer Lake, and construction of a grade control at the Mill Pond on Little Elkhart Creek to reduce sediment and sediment-attached pollutant loading. Projects are considered feasible only if the landowner and regulatory agencies approve the project and the project is economically, socially, and ecologically justifiable. This fact sheet summarizes the findings of the Five Lakes Engineering Feasibility Study.

Water Quality Investigation, Five Lakes inlet streams

Methods: Water quality samples were collected from four of the Five Lakes' inlet streams following a storm event.

Results:

- Generally, dissolved oxygen, temperature, pH, nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, and total suspended solids levels were adequate to support the aquatic faunal community.
- The streams contained elevated total phosphorus concentrations.
- *E. coli* concentrations exceeded the state standard at all four sites. Measurements were 1.75-43 times the state standard.

Grade Control and Sediment Trap Construction, Little Elkhart Creek

Problem: The Mill Pond structure has accumulated a reservoir of flocculent sediment and sediment-attached pollutants. Additionally, the structure which maintains the Mill Pond's pool elevation has fallen into disrepair and appears on the IDNR Division of Water's list of failed dams.

Potential Solutions:

- Replacement of the failed dam and hydraulic dredging
- Grade control installation and sediment trap construction
- No action

Feasible Solution:

- Stabilize the failed dam with a grade control structure.
- Create a sediment trap within the Mill Pond.

Benefits:

- The grade control stabilizes and incorporates a portion of the existing failed dam structure.
- The grade control will maintain the current pool elevation of the Mill Pond.
- The sediment trap provides additional sediment and sediment-attached pollutant storage.
- The project will result in reduced sediment and sediment-attached pollutant loading to Witmer Lake.

Livestock Fencing, J.J. Charles Drain, Hackenburg Lake

Problem: Livestock have direct access to the stream channel.

Typical associated problems include:

- Trampling of riparian vegetation
- Sloughing of streambanks
- Sediment, nutrient, and bacterial loading to the stream

Potential Solutions:

- Livestock exclusion through fencing
- Streambank stabilization
- No action

Feasible Solution:

- Fence and gate installation to restrict livestock access to the stream.
- Installation of evergreens and warm-season grass seeding along the trampled banks.

Benefits:

- Reduction in bank trampling.
- Riparian vegetation establishment thereby providing filtration for surface water runoff.
- Reduction of sediment, sediment-attached pollutants, and bacterial loading to the stream and Hackenburg Lake.

Phosphorus Load Reduction, Unnamed Tributary to Witmer Lake

Problem: The tributary delivers a high phosphorus load to Witmer Lake.

Potential Solutions:

- Construct a sediment basin in-stream or adjacent to the stream
- Plant wetland plants in the stream channel upstream of CR 765 South
- Thin/remove a thin band of silver maples adjacent to the tributary

Feasible Solution:

- No feasible solution for this project site.
- FLCA should continue to work with the landowner to develop a feasible project.